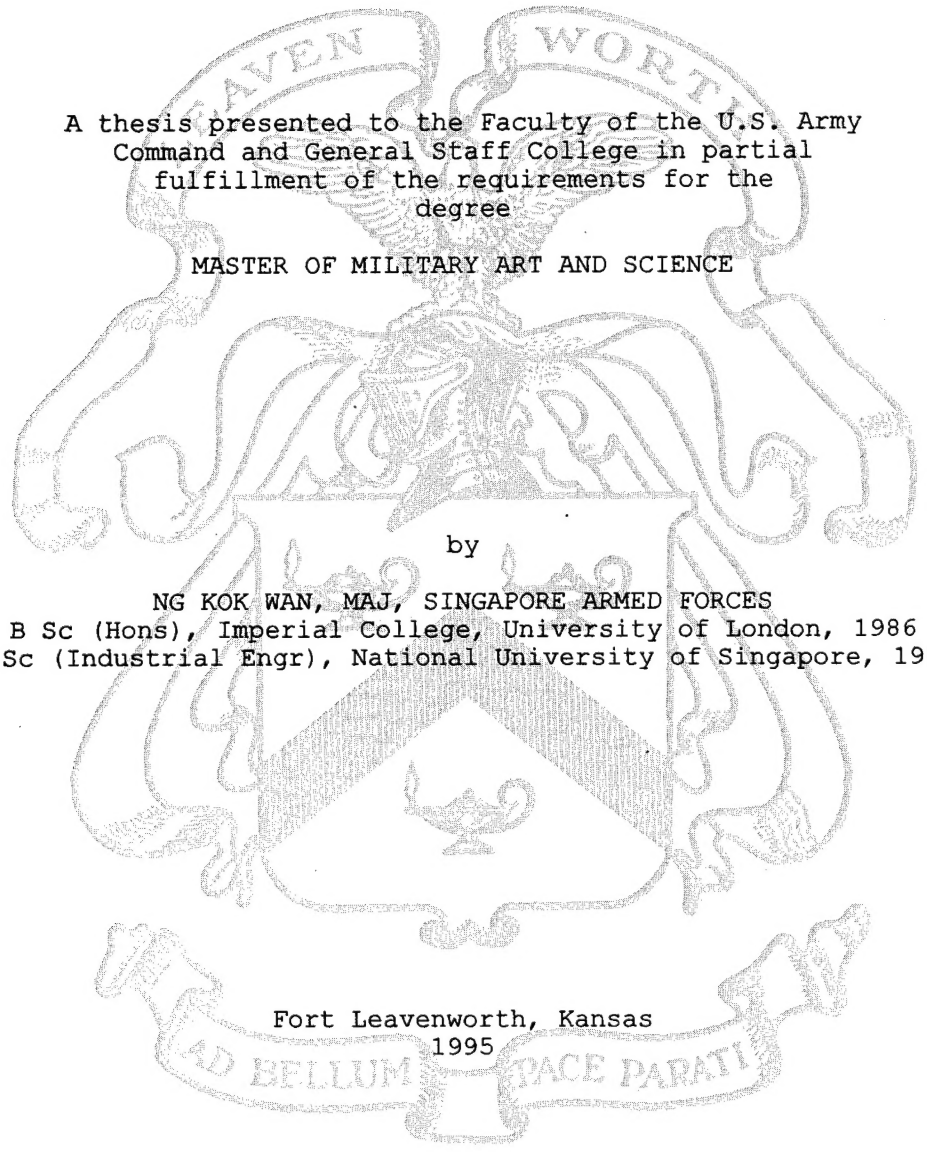
USING DECISION TREES TO DIRECT THE PLANNING THOUGHT-PROCESS: AN ENHANCEMENT TO THE PLANNING METHODOLOGY



A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements for the degree

MASTER OF MILITARY ART AND SCIENCE

by

NG KOK WAN, MAJ, SINGAPORE ARMED FORCES
B Sc (Hons), Imperial College, University of London, 1986
M Sc (Industrial Engr), National University of Singapore, 1994

Fort Leavenworth, Kansas
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THESIS APPROVAL PAGE

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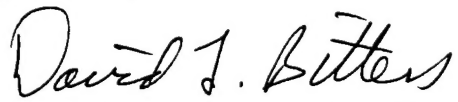

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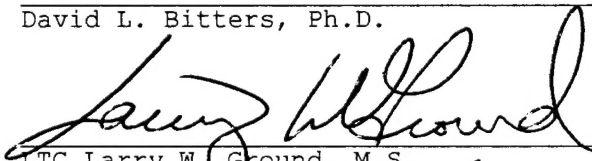

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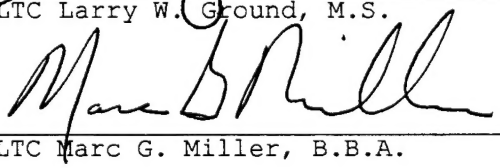

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The opinion and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

USING DECISION TREES TO DIRECT THE PLANNING THOUGHT-PROCESS: AN ENHANCEMENT TO THE PLANNING METHODOLOGY, by MAJ Ng Kok Wan, SINGAPORE ARMED FORCES, 119 pages.

This study develops a planning methodology to enhance the current procedure for analyzing friendly courses of action (COAs). It will particularly enhance the way we consider enemy uncertainty during planning.

Operations planners do not always account for possible enemy reactions rigorously when formulating friendly COAs. To overcome this, the study proposes to make the consideration of enemy options a more integral part of the planning methodology.

The planning methodology we propose is built around the concept that a COA can be represented as a branch of a decision tree. It models the choice of friendly options as decision points and enemy responses as chance events. Planners' military judgments about possible enemy actions are represented as probabilities. Endstates are rank-ordered.

The decision tree construct is used to direct the conduct of the wargame. It focuses the planning thought-process on foreclosing enemy options and inducing the enemy to take actions of our choice. The decision tree is also used as an analytical tool to compare COAs and to gain insights into how best to accomplish the mission.

This study demonstrates the use of the proposed methodology with a brigade defense scenario. It concludes that the proposed methodology enhances COA analysis and facilitates better planning.

ACKNOWLEDGEMENTS

Writing this thesis has been a very rewarding experience for me. I have been interested in the application of decision analysis to tactical problems for a few years. Thinking about the subject and writing a thesis about it, I was to discover, were entirely different propositions. It was through the encouragement and support of many people that I found the sustenance to complete this work.

I cannot, in this page, acknowledge all who have in one way or another contributed to my thesis - there were too many. I would like to give special mention to the following remarkable people who have made the difference for me.

I thank my wife, Boon Chin and my son, Ernest for their spiritual support. Without their support, I would not have succeeded in any endeavor.

I thank the members of my thesis committee, Dr David Bitters, LTC Larry Ground and LTC Marc Miller. They have given me immense encouragement and have helped, in no small measure, clarified my thoughts. Special thanks to Dr Bitters, whose meticulous guidance and patience I have come to admire and would hope to emulate.

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INTRODUCTION

> In respect of military method, we have, firstly, Measurement; secondly, Estimation of Quantity; thirdly, Calculation; fourthly, Balancing of Chances; fifthly, Victory.
>
> Sun Tzu, Art of War

Introduction

Thinking about military operations some 2,500 years ago, Sun Tzu had found the need to lay down a planning methodology. In his Art of War, he wrote of a four-step method that comprises Measurement, Estimation of Quantity, Calculation and Balancing of Chances.

Working from the Chinese manuscript, lest the essence be lost in translation, measurement meant surveying and measurement of the ground; estimation of quantity meant estimate of strength and disposition; calculation meant thinking about enemy moves and own moves; finally, balancing of chances meant weighing the options in the light of enemy possibilities.[1] He asserted that the use of this method would bring about victory.

Two and a half millennia did not dilute the relevance of his methodology to military planning. The steps in the U.S. Army planning methodology, in fact those of most modern armies, bear remarkable resemblance to this ancient method. That Sun Tzu's planning methodology stood the test of time testifies to the constancy of the fundamentals: the terrain, the enemy and self.

This thesis is about two things; the U.S. Army planning methodology and the centrality of the enemy in it.

Military officers recognize that one of the key activities in battle is the management of uncertainty and that the key uncertainty on the battlefield is generated by the enemy. War is a contest of wills. To bend the enemy to our will, we must fashion our actions to frustrate those of the enemy. It follows that a thorough grasp of enemy intentions is essential. The adversary understands this too. They will protect their intentions from discovery for as long as possible. Indeed, they will even take steps to actively deny them to us by the cunning use of deception. Try as we may, we cannot always discover enemy intentions.

Consequently, and prudently, military planning doctrine has evolved so that it advocates plans be based on enemy capability rather than intentions.[2] Military planners will fashion a robust plan that guards against all foreseeable enemy possibilities and reduces uncertainty by initiating actions aimed at discovering or, even better, limiting the adversary's options.

A planning doctrine based on enemy capability also serves a more important function. It conditions the mind of the commander and staff to recognize dangers and opportunities. Without this preparation of the mind, the commander is less likely to discern emerging patterns in the thick of battle. Lacking situation awareness, the commander is more likely to be deceived by the enemy and more hesitant to exploit good fortune if he sees it.

While there is almost universal acceptance of this planning doctrine by military staffs past and present, history is filled with examples of military units being surprised by the enemy. In many of these cases, planners either did not foresee the full range of enemy possibilities or had been mentally conditioned by a crafty enemy to plan against a single enemy intention. The former is due to incompetence and

the latter is due to inadequate planning that predisposes one's susceptibility to deception.

Historically, intelligence failures have been cited most frequently as the reason for being surprised, as if this absolves the operations planners from the cardinal sin of not fully accounting for enemy possibilities. Military planners should find this reason to justify failures unacceptable. If we cannot predict enemy intentions or forecast the outcomes of battle, then the object of military planning ought to be to think through and plan for all foreseeable possibilities, enemy and own.

Definition of the Problem

Motivation

The motivation for this thesis is that battlefield uncertainty, especially that posed by the enemy, is inadequately considered in the planning process. Several observations led to this perception.

Planning staffs appear to have unconsciously built plans based on enemy intentions rather than enemy capability. Planners tend to identify the "Most Likely Enemy Course of Action" fairly early in the planning process, usually at a stage where intelligence has not developed the situation adequately. Although this is only a subjective judgment to facilitate planning, planners often take it as fact and base friendly courses of action solely on what is perceived to be the enemy intention.[3] This tendency to exclude the possibility of other enemy intentions locks planners into a single train of thought.

Given the uncertainty, it is quite remarkable that most friendly courses of action (COAs) do not consist of more contingency or branch plans. Soldiers often lament that the plan does not survive the first contact with the enemy. This being the perception, perhaps we should make plans that are more robust against enemy reactions. In this

work, we will propose that a friendly COA is only complete when it consists of the main branch and several other branches that counteract possible enemy reactions.

The most realistic military training is a free-playing two-sided simulation exercise with a super-competent opposing force (OPFOR). Faced with an intelligent adversary, every planning mistake is accentuated by "losses" on the ground. Many of the lessons learned that units take home relate to the failure to anticipate what the enemy can do in the "battle." This observation in itself is not disturbing because units are supposed to learn from their mistakes in exercises. But if unit after unit makes similar mistakes in an area so central to our business, there should be a cause for concern.

Problem Statement

We postulate that there is a systematic error in the planning methodology; in the way planning staffs are taught to deal with enemy uncertainty when they are building friendly courses of action. This inability to grasp the array of enemy options blocks their ability to build flexible plans. Observations suggest that the planning methodology contributes to the tendency for staffs to "embark" on a train of thought that is on a single track to a final product: a synchronized operations plan.

In defining the problem, we have a glimpse of a possible solution. Taking the analogy further, it is not the fault of the train but the people who lay the tracks. In trying to fix the train, we would have missed the point. We think that the tracks should be laid through all foreseeable enemy courses of action. The planning methodology should promote travel through all these parallel tracks. The destination should perhaps be a robust plan of action rather than just one that is synchronized. Having thought through the enemy options at

various stages of the battle, the commander also will be mentally better conditioned to influence the battle.

The Planning Methodology

In the U.S. Army context, the Tactical Decision-Making Process (TDMP) is the doctrinally prescribed procedure for solving military problems. It is the thought process that undergirds the planning activity called the Estimate of the Situation. Associated with the Estimate of the Situation is a planning methodology that sought to produce a plan of action to solve a tactical problem given a mission by the higher headquarters.

The Estimate of the Situation is a four-step process. It starts with Mission Analysis, followed by Course of Action Development, Course of Action Analysis and finally the Decision. This process will be described further in Chapter Two.

In this work, we are interested in the Courses of Action Analysis (COA Analysis) step. It is here that detailed planning of the courses of action occurs. For brevity, the planning methodology that actually spans the whole Estimate will refer to that part of the methodology that accompanies the COA Analysis step.

The purpose of the COA Analysis step is to take the broad concepts of possible friendly courses of action and develop each of them into detailed plans of action. It also projects possible future outcomes of each plan. One of these plans eventually will be selected by the commander for execution.

The activities that take place during the COA Analysis involve organization of information, modeling of uncertainties, application of judgment, analysis and evaluation of options and preparation for a decision. These are the exact areas for which the discipline of decision analysis provides tools. It is at the interface between the

military tactical decision-making process and decision analysis that we will begin our search for a possible solution to the problem that we have just defined.

Primary and Secondary Questions

The primary question of the thesis is: Can we use a decision analysis approach to enhance the current method of analyzing friendly courses of action, particularly when dealing with enemy uncertainty, during the Estimate of the Situation process?

The primary question yields the following secondary questions:

1. What are the perceived inadequacies of the current method and are they widely observed?

2. What are the considerations in designing an ideal method of analysis?

3. What are the enhancements brought about by the proposed method?

Significance of the Study

The study has two distinct parts. The first part is the development of a list of attributes of an ideal planning methodology. Surveying extant literature and starting from first principles, we will take a fresh look at what a planning methodology should do for military planners. This list of attributes can be used as a starting point for further research on areas related to tactical planning.

The second part of the study develops and recommends an enhancement to the current U.S. Army planning methodology. It specifically addresses the perceived inadequacy of the present planning methodology to deal with enemy uncertainty. The proposed method will use decision trees to nudge planners into thinking through all enemy options at various stages of the plan. The rearrangement of thought

sequences is aimed at promoting insights across the enemy option domain.[4] This idea will be developed at length in this thesis. Although the proposed way of using decision tree as an aid to solving tactical problem is by no means new, its significance when set in the context of a planning methodology has not been appreciated. This thesis will demonstrate the utility of decision trees as part of the planning methodology.

Scope

It is probably beneficial to state here what this thesis is not about. Although it involves an application of decision theory, the proposed methodology is not mathematical. The depth of mathematical understanding required is well within the grasp of all military officers.

The proposed methodology is also not about quantifying the outcomes of the friendly courses of action. The use of numbers (that is, probabilities and scores given to outcomes) in the proposed methodology seeks to sharpen the decision maker's appreciation of the bounds of reality and not yield a decision directly. In other words, the use of numbers is a means not an end.

It is also not within the scope of this study to look at knowledge elicitation at any length. This can be a subject of future study. In this work, the method of quantifying military judgments is direct assignment of values on various decimal scales.

This work is not about automating the decision support system (DSS) although the list of attributes of an ideal planning methodology can be helpful to DSS developers.

Limitations

The research for this thesis is based entirely on open source, unclassified literature. As an international officer, the author's perception of the inadequacies of the planning methodology comes from several sources:

1. Unclassified material such as past Master of Military Art ans Science theses, Army Research Institute technical reports, U.S. Army Field Manuals, U.S. Army Command and General Staff College instructional material and U.S. Army periodicals.

2. Practical planning exercises with U.S. Army students during the Command and General Staff Officers' Course and conversations with U.S. Army officers with experience either as participants or controller/ observers at the National Training Center.

3. Observations from the Center for Army Lessons Learned (CALL) database.

Information gleaned from these sources is taken to be indicative of the current trends in U.S. Army tactical planning. However, not having been physically present in tactical planning situations of actual units under field conditions, the author lacks awareness of the specific context in which the inadequacies occur. So the study cannot address deeper issues that may have been the root of the problem. Thus, there is a possibility that the proposed solution will not address the problem as holistically as one would like.

On the other hand, viewing the U.S. Army planning doctrine from the outside does confer certain advantages. Living outside the paradigm sometimes provides a new perspective. However, one has to recognize that there are limitations to the applicability of alternative perspectives. The outsider's solution may not always be right for the insider.

One can speculate that perhaps U.S. Army tactical planning has focused excessively on synchronization since the promulgation of AirLand Battle Doctrine and that there may a need to balance this trend by shifting towards deeper consideration of enemy capability during planning. This is the outsider's perspective.

It is equally plausible that perhaps what is right for now is just synchronization because the U.S. Army is quantitatively and qualitatively ahead of all its likely adversaries. Mistakes made in the estimation of enemy intent can be redeemed rapidly at low cost through superior speed and firepower. If this is correct, then the premise of the thesis will be flawed. This is the limitation of taking the outsider's view.

This by no means diminishes the value of this work. An appreciation of alternative perspectives always adds clarity to the reasons why one is doing something right. It also alerts one to the changes in situation that will cause the alternative perspectives to be relevant.

Layout of the Thesis

This chapter provided the introduction to the problem that motivated the thesis. It defined what the study hopes to improve and outlined the strategy to do it.

In Chapter Two, Literature Survey and Concept Development, we shall survey the two principal areas on which the topic converges: The U.S. Army Tactical Decision-Making Process and the discipline of decision analysis. Assertions made in the Introduction chapter, will be considered in greater detail. Through analysis of the material surveyed, we will develop a list of attributes for an ideal planning methodology. The list will be the yardstick with which we will measure the enhancements that the proposed planning methodology can bring.

Chapter Three, Planning Methodology Development, develops the idea of using decision trees to deal with enemy uncertainty when planners build friendly courses of action. It will illustrate, through the use of a short vignette, the benefits of representing enemy uncertainty in this way. This chapter will conclude with the proposal of a planning methodology that we envision will enhance the current U.S. Army planning methodology.

Chapter Four presents a Case Study Analysis. The proposed planning methodology developed in the previous chapter will be applied to a brigade defense scenario as an illustration. OPLAN WHITE, a scenario employed as part of the tactics curriculum of the U.S. Army Command and General Staff Officer Course, will be used in an application of the proposed method. The potential of the new method will be evaluated.

Chapter Five, Conclusions and Recommendations, will highlight the findings of the study and recommend areas for future studies.

Endnotes

[1] With characteristic subtlety of the Chinese language, Sun Tzu used one ideogram to describe each step of this method. The four words are du, meaning to measurement or survey; liang, means to estimate quantity; shu, to calculate or count; cheng, to weigh.

[2] In this context, enemy capability means what the enemy is capable of doing. It is based on the terrain, weather, strength, the capability of his weapon systems and other relevant factors. An enemy intention is one of the ways the enemy propose to act. Thus, each enemy course of action describes one of the possible enemy intention. Conceptually, therefore, enemy capability encompasses all possible enemy intentions.

[3] Each enemy course of action describes actions the enemy will adopt given an intention. In this context, we can use Enemy Course of Action and Enemy Intention interchangeably.

[4] We coined the phrase Enemy Option Domain to mean the set of options open to the enemy given a particular situation.

CHAPTER TWO

LITERATURE SURVEY AND CONCEPT DEVELOPMENT

> ... we are prisoners of our mental images about what we think might happen in the future. If we have not thought about it, we will not consider it.[1]

Introduction

The purpose of this chapter is threefold: First, we will survey the state of the two principal areas on which the topic converges: Tactical Decision-Making Process (TDMP) and Decision Analysis (DA). In the section on TDMP, we will describe the planning methodology in current U.S. Army doctrine. We will then discuss the discipline of decision analysis with particular focus on decision trees.

Second, we will look into records that detail problems experienced by users of the current planning methodology. This will establish whether its inadequacies, as perceived in the Problem Definition section in Chapter One, exist. This will provide cues as to what enhancements are necessary.

Third, we will formulate a set of attributes of an ideal planning methodology. This will be the yardstick of our comparative study. Analysis of current and proposed methodologies will be based upon these attributes.

Tactical Decision-Making Process

Foundation of TDMP

The US Army advocates a systematic approach, grounded in the scientific method, to solve tactical problems. Known as the Tactical

Decision-Making Process, this seeks to apply thorough, clear and unemotional analysis of facts and assumptions while recognizing the need for an infusion of battle experience and military judgment. Thus, the US Army has traditionally viewed military decision making as both science and art.[2]

TDMP consists of six broad steps:[3]

Step 1. Recognize and define the problem.

Step 2. Gather facts and make assumptions to determine the scope of and the solution to problems.

Step 3. Develop possible solutions.

Step 4. Analyze each solution.

Step 5. Compare the outcome of each solution.

Step 6. Select the best solution available.

The Art and Science of TDMP

There are steps within this process, such as Steps 4 and 5, that are readily and efficiently dealt with by scientific analysis. Other steps, especially Step 3, require a stronger blend of creativity - the realm of military art.

Step 6, Selection of the Best Solution, is the final objective. The use of the term "best" suggests a scientific procedure of optimization towards certain goals. In reality, these goals are by no means tangible or simple to quantify. Various investigations into what they should be and even whence they should be derived, did not turn up universally accepted solutions.[4] Some of the suggested goals (also known as selection criteria) are ease of support by various combat elements of the Battlefield Operating System or factors such as expected casualties, duration of battle and likelihood of success. The decision maker will probably need to consider all these factors and perhaps more. However, the relative degree of importance of each factor could not be

precisely determined. Consequently, the selection of a best solution could be viewed as an art.

From this discussion of the art and science of the decision process, one sees that decision science only provides tools to facilitate decision-making. In the complex military environment, application of decision-making tools cannot produce a decision. Considerable synthesis takes place in the decision-maker's mind after the various output of decision-making tools are made available. Thus, scientific analysis is the bridge between two creative processes: the identification of possible solutions (alternatives) and the decision itself. Scientific analysis in TDMP should aim to:

1. Arrange an unstructured problem into a logical framework by which analysis can proceed.

2. Account systematically for known facts, assumptions and uncertainty.

3. Project the consequences of decision made.

4. Present clearly interactions among influencing factors.

5. Allow the application of subjective military judgment.

We shall draw on these points again in developing the criteria for comparison later in this chapter.

Estimate of the Situation

The Estimation of the Situation has been the doctrinally accepted means of tactical decision making in the US Army since 1909.[5] It was conceived as an planning activity that "culminates in a decision upon a definite plan of action." Since 1932, the US Army Field Manual, FM 101-5, has described the military decision-making process and the Estimate of the Situation. From a "train of thought sequence" in 1932 version of FM 101-5, the procedure for the Estimation of the Situation evolved into an elaborate problem solving methodology. Although the

employment of the scientific method had been the basis of the estimate process earlier, it was only in the 1968 version of FM 101-5 that TDMP in its current form was first advocated for this planning activity.

Estimate of the Situation consists of four steps which corresponds with the TDMP as shown in Table 1.

Estimate of the Situation	Tactical Decision-Making Process
Step 1. Mission Analysis.	Step 1. Recognize and define problems. Step 2. Gather facts and make assumptions.
Step 2. Course of Action Development.	Step 3. Develop possible solutions.
Step 3. Course of Action Analysis (including a comparison of courses of action).	Step 4. Analyze each solution. Step 5. Compare the solutions.
Step 4. Decision.	Step 6. Select the best solution available.

Table 1. Table of Relationship between Steps in Estimate of the Situation and Steps in Tactical Decision-Making Process.

In this work, we are interested in Step 3 in the Estimation of the Situation activity: Course of Action Analysis. Currently, U.S. Army is in the process of updating FM 101-5. The most up to date description of the Estimate of the Situation is found in the CGSC student text ST 101-5 Command and Staff Decision Processes (Jan 94). ST 101-5 describes Course of Action (COA) Analysis as a critical analysis approach that consists of three main planning activities: wargaming,

risk assessment and comparison of wargaming results. Its main objectives are:

1. To take the several broad concepts generated in the COA Development step of the Estimate of the Situation and develop each of them into synchronized COAs that are executable.

2. To gain realistic and detailed insights into possible battlefield events and activities by visualizing the flow of battle.

3. To understand the risks associated with each course of action.

4. To facilitate decision making by developing decision support tools.

The main activities of COA Analysis will be described in turn.

Wargaming

The U.S. Army uses the wargame as the principal planning activity. This attempts to project alternate futures brought about by the adoption of different COAs in interaction with an intelligent adversary. Data generated by the wargame are developed into decision support products that facilitate decision making. The U.S. Army also uses wargame to build detailed COA. By visualizing the flow of battle, planners attempt to orchestrate various battlefield elements to apply overwhelming combat power at a decisive time and place.

Through wargames, planners gain insight. Viewing the space-time relationships between battlefield entities stimulates ideas that might not otherwise emerge. Therefore, wargames both guides the planners' thought processes and allow them to add finesse progressively to the COA.

At the start of the wargame, planners prepare several possible enemy COAs and more than one friendly COAs. Enemy COAs are options available to the enemy based on their capabilities and constraints

placed upon them by factors such as terrain and weather. Friendly COAs are options available to the planners to counter anticipated enemy actions. At this stage, COAs are actions based on considerations such as the situation, the commander's intent and doctrine. Each COA is unique from the others in approach or application of force. This forces planners to stretch creativity and encourage exhaustive search for solutions.

During the wargame, planners representing friendly and enemy forces play out each friendly COA against all possible enemy COAs. The wargame is broken into shorter timeframes that correspond to critical events.[6] Players use an "action-reaction-counteraction" procedure to assess objectively the outcome of critical events of each COA. Tactical judgment, reference to historical battle data and calculations are used to estimate the outcome. Adjustments are made continually to the COA as the game proceeds, to enhance or even salvage it in the face of perceived enemy reaction. The COA is built into an executable plan and assessed for its worth as the battle unfolds.

Doctrinally, all combinations of friendly and enemy COA should be considered. Suppose there are three COA and three enemy COA developed. Then, planners should play nine wargames, taking each pair of COA and enemy COA in turn.

In practice, time is a constraint. While current U.S. doctrine recognizes this problem, it does not say how to abbreviate the process. However, ST 101-5 does give some guidance on this issue:[7]

1. Start with the set of COAs and enemy COAs that the commander specifically addresses. This could include the most promising COAs, the most dangerous enemy COA and/or the most likely enemy COA.

2. Do not assume away enemy options.

3. Focus the wargame on critical events.

4. Decide how much detail to add to the wargame based on time available. This implies planners should not sacrifice breadth for depth.

From elements elements of this guide, one concludes that even if time is a constraint, planners should not reduce their planning effort by downplaying the most important source of uncertainty on the battlefield - the enemy. In practice, planners do not always observe this rule. This could be attributed to an inadequacy in the current planning methodology. Further discussion of the inadequacies of current wargaming procedures will be presented later in this chapter.

Assessment of Risk

The second planning activity during COA Analysis is risk assessment. Planners seek to minimize two types of risks: losing men and equipment and choosing a COA that would fail to achieve the desired result.[8] ST 101-5 prescribes a five-step risk assessment procedure in which planners look for conditions most likely to cause mission failure and other accidents (including fraticide) when wargaming each COA. The procedure suggests the use of a decision tree to detect hazards associated with the COA.[9] Planners can eliminate unnecessary risks by adjusting the COA or imposing measures to minimize exposure to risks or both. Although ST 101-5 mentioned the use of decision trees to help identify risks in the COA, there was no demonstration of how this could be done.

Risk assessment is an integral part of a good planning methodology. Current planning methodology, as described in ST 101-5, recommends that "planners wargame a COA and then perform risk assessment before they proceed to the next."[10] This seem to suggest that risk is not continually assessed during planning. If the planning process does

not assess the risks as planners conduct the wargame, subsequent consideration of risks could well be cursory.

Comparison of Wargame Results

All effort during COA Analysis aims to assist the commander in decision-making. In the U.S. Army, the wargame plays the central role in analyzing COA. Planners use the wargame and the records of wargame results to frame the problem, systematically account for all relevant information, project consequences of decisions, provide a transparent framework for the application of judgment and present the results in a manner that facilitates decision. All will come to naught if records of the wargame do not portray the analysis correctly to the decision maker. A point planners often do not appreciate is that wargame record keeping is more than a means to an end; it affects the end itself. The way records are kept in fact influences the conduct of the wargame.

Recording the Wargame

Some of main purposes and functions of wargame records are as follows:

1. Wargame records capture data that will eventually help planners rank the COAs in terms of their relative merit for a decision. After a COA has been chosen by the commander, its wargame record forms the basis of the plan of action.

2. Wargame records of the chosen COA can be simplified and used as decision cues and synchonization aids for the commander during the course of the battle. The U.S. Army uses the Decision Support Template (DST) and the Synchronization Matrix from wargame records for this purpose. More elaborate descriptions of the DST and Synchronization Matrix will be presented later in this chapter.

Wargame records should also note possible branches of the COA. Due to enemy actions, opportunities or contingencies could arise. Deviations from the plan as a result of these situations are known as branches. The ability to identify and note branches in wargame records enables the commander and planning staff to do the following:

1. Promote the recognition of alternate futures and prepares the commander to guard against such eventualities.

2. Evaluate the flexibility of the COA (that is, the ability to react to opportunities and contingencies).

3. Serve as a reminder to plan for the branch.

4. Note the starting assumptions during the development of the branch plan.

As alluded to earlier, the wargame recording technique can influence the way wargame is conducted. Suppose the record is arranged in a matrix form. There is a tendency for planners to work towards filling the next box in the matrix. The subconscious goal is to fill the matrix. The record keeping method is in fact the planning methodology.[11] It is not undesirable that this should be the case if the record keeping method (be it a table or timeline) is the intended way to guide the planners' thoughts. Conversely, if the current planning methodology consistently produces COAs that are inadequate in a particular area, for instance failure to anticipate enemy actions, the cause could be the record keeping method. We shall see how record keeping is done in the U.S. Army.

ST 101-5 describes two techniques to record the wargame results. They are the Narrative Technique and the Sketch Note Technique. Under the Sketch Note technique, planners can make use of a wargame worksheet or a Synchronization Matrix.[12] The synchronization matrix has become the preferred way to record wargame results in the U.S. Army and we shall look at this in detail.

Synchronization Matrix

The AirLand Battle doctrine adopted by the US Army in the 1980s called for the synchronization of combat power as one of its tenets. Synchronization is defined in the U.S. Army capstone doctrinal manual FM 100-5, Operations as "the arrangement of the battlefield activities in time, space and purpose to produce maximum relative combat power at the decisive point."[13] Concerned with the lack of a formal way to apply the tenet of synchronization in the planning methodology, Long described a method to do so in Synchronization of Combat Power at the Task Force Level: Defining a Planning Methodology.[14] In it, he developed the format and use of a Synchronization Matrix. This has since been established as part of the planning methodology for all tactical-level planning staffs. The synchronization matrix is now used as the principal record keeping tool during the wargame.

The Synchronization Matrix concept is simple. It is a table on which all friendly and enemy battlefield activities are arranged on a common timeline. The time axis runs horizontally across the table. Each row of the table records the activities of a combat element (or Battlefield Operating System): Intelligence, Maneuver Forces, Combat Engineers (normally reflected as Mobility/Counter-mobility/Survival), Fire Support, Air Defense Artillery, Command and Control and Combat Service Support. The format of the synchronization matrix is illustrated in Figure 1.

Intelligence planners will record the initial enemy events of the enemy COA in first timeframe on the synchronization matrix. Planners will then consider friendly actions of all combat elements to counteract enemy actions and ensure synchronization. The enemy reactions to friendly actions will be recorded in the next timeframe under consideration. In turn, planners consider all friendly actions within this timeframe before proceeding to the next. Filling up the

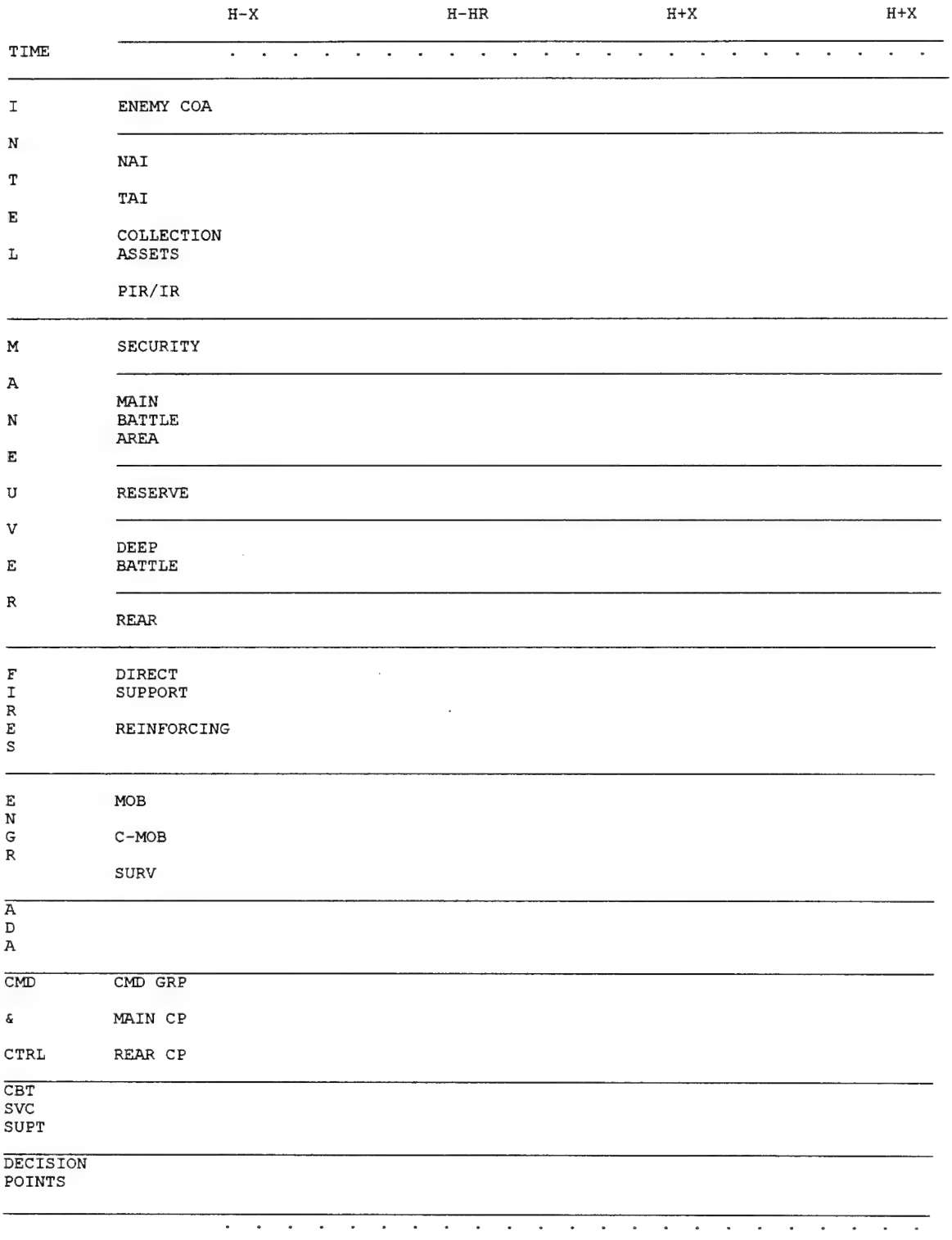


Figure 1. Format of the Synchronization Matrix

the synchronization matrix in this manner corresponds to the action-reaction-counteraction procedure for the conduct of the wargame.

Information organized in this way helps co-ordinate the actions of all combat elements in time to exploit their synergy. When planners work on a timeline, the implicit task is to reduce space to time intervals. The linkage between the two is speed. Planners apply experience and military judgment to determine the speed at which battlefield activities are accomplished. Working backwards from a point in time at which all combat power will be brought to bear, planners sequence decision points at which to launch various battlefield activities.

Fixing a Planning Methodology

It is instructive to consider how Long restructured the planning methodology to promote synchronization in tactical planning. This will illustrate the author's hypothesis that the record keeping method defines the planning methodology and influences the planning-thought process. Long perceived that the tenet of synchronization was not applied in planning. An ineffective way to solve the problem would be to append Synchronization to a long list of planning factors. Instead, he designed a record keeping method to accompany and guide the thought process. Filling the columns of the synchronization matrix and following a timeline compels planners to think about synchronization at each step. Consequently, the synchronization matrix as a record keeping method affects the planning process in a fundamental way. More than just an embedded step, it defines the planning methodology.

To further show how a record keeping method can influence the thought process, consider an alternative approach. Suppose the prescribed method were to fill in the enemy and maneuver rows first on the synchronization matrix. This would determine the maneuver plan.

Other combat elements would fill in the rest of the matrix subsequently in support of the maneuver plan. If need be, maneuver planners would make minor changes to the base plan to make support feasible. This would be a different way of arriving at synchronization; the focus of thoughts now would be on optimizing support of a maneuver plan. Most U.S. Army planners, having been schooled in the "synchronization matrix paradigm", would dismiss using the synchronization matrix this way as silly. However, this is a perfectly plausible planning methodology. In many armies, including the U.S. Army, this appears to be the predominant mode of planning for combat service support (logistics).

Nevertheless, the relative desirability of the planning methodology is not the point here. It is to show that the record keeping method has profound impact on the thought process itself. The intent of this thesis is to propose a method to improve how planners deal with uncertainty posed by the enemy. Recognizing the connection between the wargame recording method and the thought process will suggest how to enhance the planning methodology.

The Problem with the Synchronization Matrix

While the synchronization matrix is an excellent method for synchronization, it does not adequately represent uncertainty posed by enemy actions.

The matrix can deal with only one enemy COA at a time. In the planning process, a COA will be considered in relation to several enemy COAs. Correspondingly, several synchronization matrices must be developed. Users will agree that this is a time-consuming task. As the synchronization matrix became the most prevalent way to record wargame results, it also became a required product of the planning process.[15] When planning time is a constraint, there is a natural tendency to be product-oriented. With no clear doctrinal statement on how to

abbreviate the wargaming process under a time constraint, many planning staffs fall into what could be described as the "Most Likely Enemy COA Trap."[16] Planners work with one enemy COA so as to produce a reasonably detailed synchronization matrix for presentation. This can cause the commander and staff to overlook enemy options not perceived as "most likely." Planners tend to think deterministically.

Another problem is that variations to the enemy COA are difficult to represent in the synchronization matrix. Like friendly forces, the enemy will have branches to their plans. Since the synchronization matrix does not allow planners to represent enemy COA branches easily, this inhibits them from considering the full range of enemy options during planning.

Considering one enemy COA at a time also presents some practical problems. When a single COA is wargamed against several enemy COAs, several synchronization matrices needs to be developed; one for each pair of friendly and enemy COAs. Since planners build the COA as each wargame proceeds, the single COA could evolve on significantly different paths because it is pitted against different enemy situations. How to collate these few different paths into branches of the same COA can be a problem. Planners have to look for the decision points for different branches, the split points of different routes and perhaps to adjust the positioning of forces and so on.

There is a more fundamental problem when planning is done against one enemy COA at a time. It is about the ease with which planners can form insights during the conduct of the wargame. Planners are less likely to see what options are open to the enemy at a particular point in the battle when they work through enemy COAs one at a time. Not being able to see the full range of enemy options, planners are less likely to see what appropriate friendly actions to take in order to accomplish the mission.

If we have a methodology that cues planners to look at all possible enemy options at the time under consideration, they can take positive actions to foreclose enemy options rather than reacting to the enemy. They can also determine which option to induce the enemy to take. These insights are possible because we are "working across the enemy option domain." It is not that planning with synchronization matrix does not allow this to happen. The suggested approach make such insights more accessible to the average planner. The idea of working across the enemy option domain is not new. The event template is in fact constructed on such a concept.

Event Template

The Intelligence Preparation of the Battlefield (IPB) is the process by which the intelligence staff supports military decision making. FM 34-130, Intelligence Preparation of the Battlefield is the U.S. Army doctrinal manual that describes how this is done. One product of this process is the formulation of enemy COAs. Doctrine requires planners to identify the full set of enemy COAs available to threat forces to avoid being surprised. Intelligence planners consider enemy doctrine, environmental factors (such as weather and terrain) and enemy intent to come up with a set of enemy COAs. Collectively, these describe what the enemy is capable of doing.

Intelligence planners depict enemy COAs graphically by means of situation templates. The essential elements of the situation templates are geographic locations of enemy forces, their expected maneuvers, locations of their intended objectives and time phase lines to relate time and space. Each enemy COA is depicted by one (or more if necessary) situation templates.

Doctrinally, the U.S. Army takes the conservative approach and plans on enemy capability rather than enemy intentions. In a step

consistent with this approach, individual situation templates (each representing an enemy COA) are superimposed to produce the event template. This procedure epitomizes what we have earlier called "working across the enemy options domain." The contrasts between individual situation templates stand out as areas of interest in the event template. Intelligence planners gain numerous insights from the event template. These include key geographic locations or time windows at which enemy forces need to choose between their options. For the intelligence planner, observing the enemy at these points will enable him to piece together the enemy intent. The event template is the basis of the intelligence collection effort.

For the operations planner, it is at these geographic locations and time windows that appropriate actions can leverage disproportionate effects. We can foreclose the enemy's most favorable options or force them to take unfavorable options. Working across the enemy option domain not only prevents being surprised but promises opportunities to seize the initiative and dictate the tempo of the battle.

Decision Support Template

For completeness, we include a brief discussion of the Decision Support Template (DST). The Decision Support Template is a decision making aid for the commander in battle. It consolidates all essential information and decision cues required by the commander to exert influence in a dynamic battlefield. It is therefore the ultimate product of the planning effort. The basic elements of information in the Decision Support Template are:[17]

1. An overlay based on the operational map that includes projected enemy and friendly schemes of maneuver with branch plans.
2. The Event Template.
3. The Synchronization Matrix of the selected COA.

4. Commander's Critical Information Requirements (CCIR).[18]

These items help the commander to rapidly make sense of the fragments of battlefield information flowing to him. He can then build an accurate picture of the situation upon which he can make changes to the plan and influence the battle. Part of this process involves a thorough grasp of the options open to the enemy at various points in the battle. If the commander has a robust plan that has anticipated these enemy options, effort required to effect battlefield command and control will be reduced.

Field Researches

The U.S. Army Research Institute for Behavioral and Social Sciences (ARI) established the Fort Leavenworth Field Unit to enhance command and control capabilities of the Army. ARI research findings in tactical planning performance in the U.S. Army from 1973 to 1993 were covered comprehensively in Fallesen's Overview of Army Tactical Planning Performance Research.[19] This report drew on studies of tactical planning performance by ARI, contracted sources and the U.S. Army Center of Army Lessons Learned (CALL). Its conclusions support our perceptions of the problems encountered in the tactical planning process. Following are highlights of research findings relevant to this work.

In time-constrained planning, there is uncertainty about how to tailor the tactical planning process when time is too short to do the entire Estimate of the Situation. Under these circumstances, there tends to be increased focus on the end product. Falleson reported that a full estimate process was never used in the U.S. Army Command and General Staff Officers' Course exercises he observed.[20] Student effort appeared to be focus on synchronization matrix completion. Similar tendencies surfaced in the field. Here, the emphasis was on preparation and execution. A battalion commander said:

> ... Increased decision making time directly reduces planning time, rehearsal time and subordinate planning and preparation time. These latter activities have much higher payoff than the possibility of arriving at an incrementally better course of action.[21]

These observations support an earlier point: important planning factors (for example, the synchronization matrix) must be an integral part of the product. For the planning factor to be considered, they must lie on the path of least resistance for the staff.

This also shows the direction U.S. Army doctrine can take on abbreviating the tactical decision-making process. ARI tactical planning researchers speak favorably about using Naturalistic or Recognition Primed Decision-Making (RPD)[22] in situations where rapid decisions are required, particularly in lower echelon commands. In the RPD process, the decision maker chooses on a single option rapidly. This is generated from prior experience and is evaluated to see if it satisfies minimal criteria of the current problem. A process of "progressive deepening" is then used to construct the complete plan of action. In line with this development, the proposed enhancement to the planning methodology should be capable of supporting an abbreviated decision-making process.

Fallesen's report also observed that planners frequently did not predict enemy reactions nor estimate the probability of mission accomplishment.[23] This was attributed to lack of experience as well as to the lack of data for wargame projections, especially in the area of attrition. Participants in the study also gave a "not very confident" rating to their resultant estimates (2 on a 5-point scale of confidence).

The author agrees that lack of confidence in wargame data can inhibit planners from making predictions about the enemy and probability of the mission accomplishment. However, ARI researchers and participants of the study probably missed the point about the use of

probability figures and quantifying the outcomes in wargames. It is easy to lose sight of the means and the ends of wargaming. Numbers sharpen the mind to the issues by adding visual impact to them. They are not intended to be absolute predictions about the future.

Fallesen also reports that in 1992, according to CALL, 75% of the divisions and corps undergoing war fighter exercises (Battle Command Training Program) did not develop sequels. Fifty-three percent of the units did not use IPB products to develop contingency plans. These instances of incomplete planning are probably due to a poor grasp of the full range of enemy options.

In Observation on Command and Staff Performance during CGSC Warrior '91, Fallesen and Michel found that:

> The lack of contingency planning was a sign of failure to make plans more robust considering the lack of certainty about enemy intentions.[24]

They further say that:

> The students gave very little thought to how the initial plans could go wrong. They were never observed considering branches in either enemy actions or their own actions.[25]

Fallesen cited other sources to show that these observations were not restricted to CGSOC students but also extended to division staffs.[26]

The failure to develop contigency plans can be attributed to current planning methodology. The synchronization matrix considers one enemy COA at time. This does not cue planners to consider other enemy options that can exist at various points in the battle. Even if other enemy options are identified, the urge to complete the synchronization matrix causes planners to come back to the other enemy options later and deal with them as contigency plans. Thus, planners unwittingly fall into the "most likely enemy COA trap." In fact there is no basis, except for the planners' preconception, for saying that one enemy option or another is more likely. Since contingency plans are unconsciously

accorded a lower priority, they may never get due consideration or may be disregarded amongst other pressing planning activities.

Fallesen recognized difference in individual expertise as an important factor in the performance of planning tasks. He cited the work of MacMillan, Entin and Serfaty, who compared quality of planning performance by 3 experts and 26 other military officers.[27] [28] In comparison, the experts:

1. Generated more detailed course of action.
2. Focused immediately on critical unknowns.
3. Understood the complexity of the situation better.
4. Understood the sequencing of events better.
5. Had more concern about outcome risks.
6. Identified more potential problems.
7. Anticipated changes in the tactical situation.
8. Planned contingency operations.

These are the essence of successful planning. The main purpose of a planning methodology is to lead planners through these important points as a matter of course. As planners apply this methodology, it becomes habitual to think like an expert. Following a well designed planning methodology, an average planner has the greatest likelihood of producing an expert plan.

Summary of Investigation into the Planning Methodology

In summary, let us recapitulate the key conclusions of our investigation into the planning methodology.

Analysis of the U.S. Army Tactical Decision-Making Process and Estimate of the Situation[29] showed that different parts of the process draw on different proportions of creativity (art) and analytical ability (science) of the planner. Planning activities leading up to and

including COA Development are viewed as creative processes. Arguably, the choice of a course of action also lies in the realm of military art. The activities that bridge COA Development and the decision require objective evaluation and lend themselves more readily to scientific treatment. These include the analysis and comparison of COAs. It is on this part of the Estimate of the Situation (and its corresponding part of the TDMP) that this thesis focuses.

Looking at the position COA analysis and comparison occupy in the TDMP, we conclude that the purpose of the planning activities in this step of the Estimate of the Situation should include framing the problem, systematically accounting for known parameters, projecting outcomes of decisions, presenting parameters influencing the outcomes and finally applying military judgments. The procedure for doing these activities is called the planning methodology in this thesis.

In the U.S. Army, the wargame is the key component of the planning methodology. It attempts to integrate all relevant information to project the outcomes of each COA in view of enemy capability. Although the wargame attempts to predict outcomes, it is but a means of gaining insights into the tactical problem. In U.S. Army application, the wargame is also used as a means to build a detailed plan.

Wargame records are kept to capture key assumptions and data generated by the wargame. These serve as a basis for selecting a COA and formulating a plan of action, and can be used as a decision cue for the commander to exercise battlefield command and control.

We showed that the wargame recording method has deeper significance. It can drive the way a wargame is conducted and indirectly influence the train of thought during the wargame. Thus, we surmise that the recording method defines the planning methodology. Using Long's 1989 work on the synchronization matrix as an illustration, we have seen how a planning methodology can be effectively improved to

address a perceived problem. We argue that the best way to remedy a deficiency in the planning process is to change the recording method.

The synchronization matrix is examined to see if it has caused the present inadequcies in the planning methodology. The synchronization matrix allowed planners to look at only one enemy COA at a time. So, planners are denied insight into enemy options at each stage of the battle. The inability to form insight "across the enemy option domain" contributes to a poor grasp of possible enemy actions. This in turn leads to a failure to anticipate.

A survey of results of field studies conducted on tactical planning confirmed many of our observations. Failure to plan for contingencies appeared to be prevalent.

One particularly useful study (MacMillan et al) developed a list of characteristics of expert planning. A good planning methodology should guide inexperienced military officers through the steps in the expert planning process so that they too can turn out consistently good plans.

We commented that it is futile to attempt to improve a planning methodology by appending another heading to a list of planning factors. The planning methodology must be designed so that the planner works through the prescribed tasks and so that the product will bear the characteristics of a robust plan. This is analogous to working through the synchronization matrix to produce a synchronized COA.

From the foregoing findings, we can now construct a list of attributes of an ideal planning methodology. This is to serve as a yardstick by which proposed enhancements to the current methodology can be measured.

Attributes of an Ideal Planning Methodology

1. It must serve the functions of the COA Analysis stage of the Estimate of the Situation. They are:

a. To arrange an unstructured problem into a logical framework.

b. To account systematically for known facts, assumptions and uncertainty.

c. To project the consequences of decision made.

d. To present clearly interactions among influencing factors.

2. It must allow the application of subjective military judgment.

3. It must consider explicitly all foreseen enemy COAs and account for the associated uncertainties.

4. It must retain the wargame as a central feature and must leave a wargame record that can:

a. Allow synchronization of combat elements and sequencing of the battlefield events.

b. Facilitate the action-reaction-counteraction procedure.

c. Allow consideration of all feasible enemy options at any time.

d. Allow branches of a COA to be represented and maintain their visibility throughout the planning process.

e. Provide decisions cue for command and control purposes.

5. It must present wargame results such that it makes insights more accessible to the planner.

6. It should facilitate identification of potential problems, critical events and key intelligence gaps in the COAs.

7. It should allow sensitivity analysis so that the effects of changing assumptions can be appreciated.

8. It should encourage planners to think about uncertainty and alternate outcomes. Planners could be thus be primed to anticipate problems and opportunities in battle.

9. It should be capable of supporting an abbreviated decision-making process, such as RPD.

10. It should support clarity in decision-making by allowing the user to trace how the decision was made.

11. It should be perceived (by the planning staff) to be worth the time and effort to produce.

Decision Analysis

We have established that the main inadequacy in the Estimate of the Situation process is the way planners deal with enemy uncertainty. One branch of decision analysis studies normative decision making. Its goal is to pursue clarity of action.[30] This gives the decision-maker the assurance that he has chosen the best decision based on all currently available information and consistent with the principle of choice he has selected.[31] This process provides the decision maker a systematic and a transparent way of making a decision. It tracks not only the decision but also how the decision is made.

In this work, the focus is not so much on the decision itself, but on the process of organizing available information with a view toward gaining insights. The best solution that the decision analysis tool finds can of course be the basis of the decision. More importantly, through sensitivity analysis, planners can look at how the solution will change when there are changes to the input data (that are based on military judgment). This type of higher order analysis opens the minds of planners to better deal with uncertainty, and focuses them on key information gaps.

In this section, we survey the subject of decision analysis to look for tools that can serve our purpose. We want to identify those most adept at modeling interactions between courses of action of two adversaries. Two that are particularly well suited are: Game Theory and Decision Trees. We will look at them in turn.

Game Theory

Game theory was established as a branch of mathematics to deal with conflicts involving two or more players. It was introduced by von Neumann and Morgenstern in Theory of Games and Economic Behavior.[32] Game theory involves independent choices in competitive situations involving rational decision makers. In the simplest form, two adversarial players, each having a choice of two or more strategies (courses of action), visualizes the outcomes of all combinations of strategies. The outcome of each pair of strategies is diametrically opposite in utility (military worth) to that of the adversary. That is, a gain for Player A is a loss to the same degree for Player B. This is known as a zero-sum game. Using a procedure called the maximin theory, the best strategy is selected.

Game theory is rich in the breadth of situations it can cover. It extends to situations of increasing complexity: situations where there is a need to keep the choice of strategy secret (mixed strategies), games involving more than two players (n-person games) and games where players have different motives (nonzero-sum games). The scope of this thesis precludes a detailed exposition of this interesting and extensive field of study. However, an excellent introductory survey can be found in Zagare's Game Theory: Concepts and Applications.[33]

Military applications of game theory have been considered by Haywood.[34] He retrospectively modeled the essence of the decision

problems in the Battle of Bismarck Sea in 1943 and the Battle of Avranches Gap in 1944 as two-player zero-sum games.

While game theory is a powerful method for analyzing and prescribing a decision, the author finds it difficult to use as a natural means of recording a wargame. It does not permit adequate modeling of the dynamics of battlefield actions for the purpose of building the COAs. It is also difficult to use for the purpose of sensitivity analysis.

Decision Tree

The decision tree method views the decision problem in terms of a sequence of decision points, chance events and outcomes. These are arranged in chronological order and graphically presented as a tree with branches. Emanating from decision points are the possible alternatives (COAs) available at that time. Emerging from the chance nodes are branches representing possible chance events. Attached to each branch is a probability figure denoting the likelihood of its occurrence. Chance events are by definition events beyond the decision maker's control. As the situation unfolds, only one of the chance events associated with the chance node will occur. The principle of choice employed in decision trees involves optimizing the expected utility.

The decision tree method finds many applications in the military environment. It is taught as part of the foundation course in the U.S. Army Command and General Staff Officers' Course. Student text ST 25-1, Resource Planning and Allocation, devotes a chapter to this technique.[35] In the Command and General Staff Officers' Course, decision trees are used to model numerous military problems. Major classes of applications include determination of tactics and weapon mix, formulation of rules of engagement, military resource allocation and the

choice of a COA under the uncertainty of enemy actions. The last class of application is of primary interest in this thesis.

The number of military examples shows that military officers have no difficulty thinking in terms of the decision tree formalism. The explicit representation of influencing factors and the chronological arrangement of decisions, chance events and outcomes appeal to their intuition.

However, it appears that the decision tree method has not enjoyed wide application outside the classroom environment. The use of decision trees in the TDMP receives only a brief mention under risk assessment section of ST 101-5.[36] The lack of doctrinal advocacy may be a reason. Another reasons may be that planners did not see the potential of decision trees as a tool for planning and analysis.

In the following chapters, we will attempt to use the decision tree as the principal component of the planning process. We will explore its potential to correct the current deficiencies in dealing with enemy uncertainty during planning. The quality of the enhancements to the planning methodology, if any, will be assessed.

Conclusion

In this chapter, we surveyed extant literature on the U.S. Army tactical decision-making process, the tactical planning process and decision analysis. We did this with a view toward enhancing the current planning methodology, that deals with the COA analysis stage of the Estimate of the Situation.

We started with the proposition that there are inadequacies in the way planning staffs deals with enemy uncertainties during planning. Some manifestations of these can be seen in operations plans that do not cater to contingencies, branches and sequels. These plans frequently fail to anticipate enemy actions during battle. Soldiers have low

confidence that the plan can "survive the LD/LC" (that is, the startline of combat operations).

The literature survey suggests that our proposition is correct. It also yields insights into the causes of the problem and how it can be resolved. A list of attributes of an ideal planning methodology is distilled from the findings of the survey. This list provides a yardstick to measure the effectiveness of our proposed enhancements to the planning methodology.

Endnotes

[1] John L. Petersen, "Forecasting: It's Not Possible," Defense Intelligence Journal Vol 3 No 2 (Fall 1994), (The Joint Military Intelligence College Foundation, VA), 37-45.

[2] U.S. Army Command and General Staff College, ST 101-5 Command and Staff Decision Processes, student text, (Fort Leavenworth KS: USACGSC, Jan 94), I-2-1

[3] Ibid., I-2-1.

[4] John A. Advise, Tactical Decision Making: A Proposed Evaluation Criteria Model for the Infantry Battalion's Tactical Estimate during Offensive Operations, MMAS thesis, (Fort Leavenworth KS: U.S. Army Command and General Staff College, 1993); Walter E. Kretchik, The Manual Wargaming Process: Does our Current Methodology Gives Us the Optimum Solution?, monograph, (Fort Leavenworth KS: School of Advanced Military Studies, AY 1991-1992); James M. Milano, Tactical Wargaming after H-Hour: An Unstructured Mental Process, monograph, (Fort Leavenworth KS: School of Advanced Military Studies, AY 1991-1992); Kevin B. Smith, The Calculus of War: The Role and Use of Quantitative Decision Aids at the Tactical Level of War, MMAS thesis, (Fort Leavenworth KS: U.S. Army Command and General Staff College, 1993); W. Edward Shirron, An Optimum Method of Wargaming a Tactical and Operational Course of Action as an Integral Part of a Corps Commander's and G3's Estimate of the Situation in a Time-Compressed Environment, (Fort Leavenworth KS: U.S. Army Command and General Staff College, 1984).

[5] Rex R., Michel, Historical Development of the Estimate of the Situation, U.S. Army Research Institute Research Report 1577, (Fort Leavenworth KS: Fort Leavenworth Field Unit, Oct 1990) 3.

[6] Critical events are identified by planners as important periods of a battle. For example, critical event can include river-crossing, actions on the objective and joint force actions in an engagement area.

[7] ST 101-5, I-8-1 to I-8-11.

[8] Ibid., I-8-24.

[9] Ibid., I-8-25.

[10] Ibid., I-8-24.

[11] This statement is a generalization. In the US Army, the planning methodology is based on wargames. Therefore the record keeping device is the wargame record (of which synchronization matrix is a type). Elsewhere, the planning methodology could be based on detail examination of the terrain, time and space and relative combat power. Other types of record keeping devices, such as a graphical portrayal of the COAs with time phase lines, could well be more efficient. In any case, the record keeping device is the manifestation of the intended thought process. If one inadequately mirrors the other, the methodology would be hard to follow.

[12] ST 101-5, I-8-9.

[13] U.S. Army, Field Manual 100-5 Operations (Washington D.C.: Headquarters, Department of the Army, June 1993), 2-8.

[14] Clyde L., Long, MAJ, U.S. Army, Synchronization of Combat Power at the Task Force Level: Defining a Planning Methodology, MMAS thesis,(Fort Leavenworth KS: 1989)

[15] ST 101-5, IV-4 to 5, In the recommended briefing format, Synchronization Matrix is required for the wargame brief and the decision brief. Since synchronization matrix of the chosen COA will form part of the Decision Support Template, it is also required for the OPLAN/OPORD brief.

[16] In discussions with CPT(P) Dean Taylor, MI, US Army, in February 1995, CPT Taylor coined the phrase "Most Likely Enemy Course of Action Trap." Like the author, he too was concerned about planning staffs sinking into a mental rut. Planners fall in the "trap" when all COAs are, for reason of expediency, only considered against what is assessed to be the most likely enemy COA. His first-hand experience as an observer/controller in NTC indicated that falling into this trap is prevalent in units. These units are most susceptible to "anticipation" failure.

[17] ST 101-5, I-10-11.

[18] Commander's Critical Information Requirement are important elements of information required by the commander to accomplish the mission. CCIR are in the form of questions determined by the commander early in the planning process. A large part of the intelligence collection effort is devoted to answering these questions.

[19] Jon J. Fallesen, Overview of Army Tactical Planning Performance Research, Technical Report 984, (Alexandria, VA: U.S. Army Research Institute for Behavioral and Social Science, 1993).

[20] Ibid., 13.

[21] Ibid.

[22] Gary A. Klein, "Strategies of Decision Making," Military Review (May 1989): 56-64.

[23] Fallesen, 22.

[24] Jon J. Fallesen and Rex R. Michel, Observation on Command and Staff Performance during CGSC Warrior '91, ARI Working Paper LVN-91-04, (Fort Leavenworth, KS: U.S. Army Research Institute for Behavioral and Social Science, 1991).

[25] Ibid., 5.

[26] Fallesen, 27.

[27] MacMillan, Entin and Serfaty, Defining and Assessing Expertise in a Complex Domain - Measures based on Theory, 37th Annual Meeting of the Human Factors and Ergonomic Society (Oct 11-15, 1993).

[28] Fallesen, 36.

[29] For clarity, the relationship between the Tactical Decision Making Process (TDMP) and the Estimate of the Situation (EoS) is explained: the EoS is the series of planning activities to arrive at a plan of action while the TDMP is the prescribed thought process for solving general military problems. In this thesis, we are interested in cases when the TDMP is applied to the EoS.

[30] K.L. Poh, "An Overview of Decision Theory," Student Text for Decision Analysis module of the Masters of Science degree course, (Singapore: National University of Singapore, July 1993): 1.

[31] The normative model of decision making prescribes the course of action that the decision maker should take to achieve goals most efficiently. The decision is based on a set of decision norms (therefore normative). Two examples of such norms are the principle of optimizing the expected utility and the maximin theory. These are also known as principles of choice. Normative decision making models yield an optimal solution, if one can be found, given all relevant information and a set of norms to follow. Normative decision making constrasts with descriptive models. The latter describes the outcome of the alternatives. A decision is made based on the evaluation of the described outcomes corresponding to a set of selection criteria. Usually, descriptive models are used when normative models are not applicable.

[32] John von Neumann and Oskar Morgenstern, Theory of Games and Economic Behavior, (Princeton, NJ: Princeton University Press, 1944).

[33] Frank C. Zagare, Game Theory Concepts and Applications, Sage University Papers series on Quantitative Applications in the Social Sciences, series no. 07-041. (Beverly Hills CA: Sage Publications, 1984).

[34] Oliver G. Haywood, "Military Decision and Game Theory," Operations Research, Vol. 2 (November 1954), 365-385.

[35] USACGSC, ST 25-1, Resource Planning and Allocation, student text, (Fort Leavenworth KS: U.S. Army Command and General Staff College, 1995). 6-1 to 6-22.

[36] ST 101-5, I-8-25.

CHAPTER THREE

PLANNING METHODOLOGY DEVELOPMENT

> Reasoning is commonly associated with logic, but it is obvious that the implications of what is ordinarily called logic are meager indeed when uncertainty is to be faced. It has often been asked whether logic cannot be extended, by principles as acceptable as those of logic itself, to bear more fully on uncertainty.
>
> Savage, The Foundations of Statistics.

Introduction

In this chapter, we will develop a planning methodology that addresses the uncertainty posed by the enemy more adequately than the current one does.

For completeness, the chapter will begin with a brief primer on decision trees. This will be followed by an illustration of how the decision tree method solves a simple but significant tactical problem.[1] The discussion that follows highlights how the idea of thinking across the enemy option domain helps planners form insights.

From conclusions drawn from the solution of the simple tactical problem and from ideas developed in Chapter Two, we will extend the method to deal with courses of action with several decision points.

Decision Tree Primer

A decision tree is a graphical representation of the essence of a decision problem. The problem is modeled as a sequence of decisions, chance events and outcomes. These are arranged in chronological order.

Figure 2 shows a decision problem represented in decision tree form. This is the well-known party problem, used by Howard as an example to teach decision analysis.[2] The hostess, Jane, wants to decide the best location to hold her party given the uncertainty of weather.

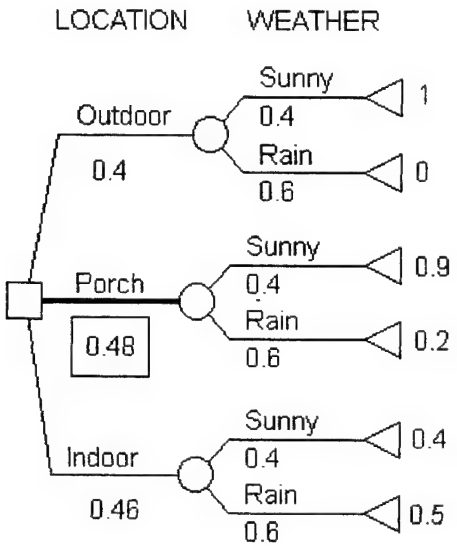


Figure 2. Jane's Decision Tree

Decision points are represented by squares in the decision tree; chance events are represented by circles. In the party problem, the decision pertains to the location of the party and the chance event involves sun or rain as states of nature. Lines join decision and chance events. Lines originating from a decision point (square) represent courses of action available. The hostess, has the choice of holding the party outdoors, on the porch or indoors. When a

particular course of action has been adopted after decision analysis, the line representing this course of action could be made bold or an arrowhead could be added to indicate that is the way to go. Lines originating from a chance event (circle) represent the different outcomes that could happen at this point. Numbers appear on each of the lines. These are probabilities that the corresponding event will happen. Here, the probability of sun is 0.4 and the probability of rain is 0.6. The sum of probabilities originating from a chance event node is always 1.

There is an outcome at the end of each branch of the decision tree. Each outcome is characterized by the set of decisions and events along its path. In the party problem, there are six possible outcomes: outdoor party in the sun, outdoor party in the rain, porch party in the sun and so on. For analysis, a number is attached to each outcome. This is known as the utility. It represents how much one would prize this outcome over another. Utility is frequently represented by dollar values. However, in general, utility could be some ordered scale on which the relative desirability of outcomes could be measured. Jane obviously values an outdoor party in the sun most by assigning a utility of 1 to it. The least desirable outcome is an outdoor party in the rain, to which a utility of 0 is assigned. The assignment of values to the outcomes could be as objective as a formula to calculate profit margins or as subjective as a numerical score to denote one's feelings about various outcomes.

The purpose of decision trees or decision analysis in general is to optimize (that is, either to maximize or minimize) the utility. Optimization is done by choosing the path that yields the best expected value. So, if the utility represents risk, one would want to choose the course that minimize the expected risk. If the utility represents profit, one would want to choose the course that maximizes expected

profit. The expected value is the sum of the products of utilities of outcomes and their probabilities of occurrence, over all possible outcomes. In Jane's decision tree, the expected value for a party outdoors is computed by (0.4 x 1 + 0.6 x 0) = 0.40. Similarly, the expected value for a party on the porch is (0.4 x 0.9 + 0.6 x 0.2) = 0.48. Using the same computation procedure, the expected value for a party indoors is 0.46. This process is sometimes called rolling back the tree because the decision maker computes the expected value backwards along the branches of the decision tree. The party problem requires the maximization of utility. Hence, Jane should decide to hold her party in the porch under current assessment of uncertainty about the weather because this course of action yielded the highest expected value (utility) of 0.48.

Use of Decision Tree in Tactical Problems

The idea is to decompose a course of action (COA) into component battlefield decisions and activities and arrange them sequentially onto a decision tree. Possible enemy reactions in the decision tree are modeled as chance events. Using judgment, the planner assigns the likelihood of occurrence (in the form of a probability) to each enemy option. Having constructed the decision tree, the planner then assesses the merit of each branch. On a scale of 0 to 10, the planner ranks the projected outcomes of each branch. Zero means the least desirable outcome with respect to the mission and ten means the best outcome. This is a purely military judgment. The next step is to roll back the decision tree to compute the expected value associated with each COA. In a tactical problem, the objective is to find the COA that will yield the best outcome. Thus, the planner should choose the branch with the highest expected value.

We have said that the intent of using numbers in the planning methodology is not to quantify the outcomes and make a decision based on subjective data but to gain a more thorough appreciation of the interactions between enemy and own actions. So far we have a ranking of COAs based on the planner's military judgment about the likelihood of occurrence of enemy COAs and values representing the relative desirability of these outcomes. We should not base our decision solely on subjective data.

In our context, we should also be careful not to base decisions solely on the expected value. Using the expected value to select a COA implies that we will get a superior outcome in the long run after many repetitions of the COA. However, we can only fight a battle once.

The analysis should continue with questions such as:

1. What led to the choice of this COA? What are the contributions of each branch to the expected value?

2. Are the expected values sensitive to slight changes in the quantities representing the military judgments about the enemy? If so, what are these judgments and by how much must they change to affect the decision? What are the ranking of the COAs as a result of such changes?

3. Are the value judgments of the outcomes consistent with the commander's intent? Are the expected values sensitive to changes in the value judgments about the outcomes? If so, by how much must they change to affect the decision?

From these questions about the sensitivity of the decision tree solution, one can gain an understanding of how enemy uncertainty affects our tactical solution. By means of sensitivity analysis, the planner can also focus on the key uncertainties to get the maximum incremental return.

Looking at the full range of outcomes reflected by the decision tree broadens the planner's mind to the bounds of reality. Sensitivity

analysis on the value judgments sharpens the appreciation of the commander's intent for the battle.

Current planning methodology in effect holds an enemy COA constant while working through an own COA, then proceeds to the next enemy COA. Planners may overlook some enemy options. Decision tree representation allows the planner see all possible enemy options at a particular time. In this way, the decision tree heightens the planner's situation awareness and thus enables more flexible plans to be built.

A Simple Tactical Problem

To illustrate the potential of the decision tree, we will model a simple tactical problem in which the COAs involve a single decision. This scenario comes from a planning exercise used in tactical instruction in the United States Army Command and General Staff Officers' Course (CGSOC).

A Division Planning Vignette

Briefly, the scenario is as follows:[3] The enemy consists of two Krasnovian motorized rifle divisions, advancing abreast towards the west. The Blue force, X Corps, consisting principally of one mechanized division and two armor divisions, is mounting a mobile defense to destroy Krasnovian (Red) forces. The scenario is set in Germany. The Corps' concept of operation is to use the mechanized division as an anvil while holding a two-armor divisions striking force to hit the advancing motorized rifle divisions from the south flank. X Corps' deep and covering force battles will shape the battlefield in such a way that the southern Red division will move substantially faster than the northern Red division. The Blue two-division striking force can then attack the enemy piecemeal; the southern Red division first, then the northern Red division.

Students play the role of the staff of one division executing the attack. The decision problem occurs in the period between the southern fight and the northern fight. Blue forces are in a hasty defense posture after the first fight (in which we destroyed the southern Red division). There is uncertainty about how the northern Red division would react to the destruction of the southern Red division and the presence of Blue forces on their south flank. The sketch map depicting the situation is at Figure 3.

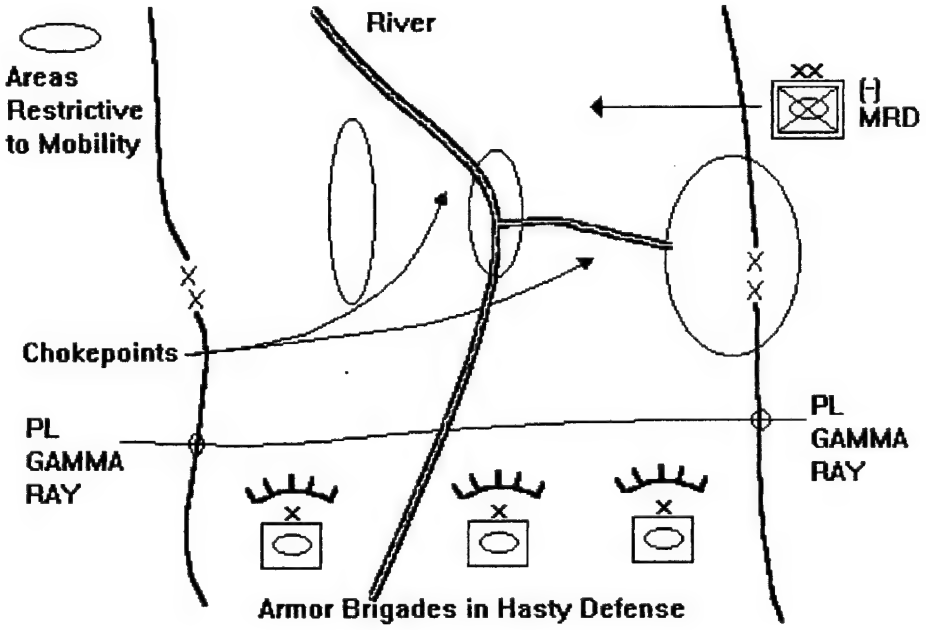


Figure 3. Sketch of the Situation: the Division Planning Vignette.

There are two chokepoints between the Blue forces and the anticipated enemy axis of advance.[4] The intelligence officer's (G2) analysis yields three possible enemy courses of action, as follows:

Enemy Course of Action 1: Red sees Blue forces as substantially weakened by the fight with the southern Red division. Being depleted in combat power, Blue forces are thus in hasty defense. The northern Red division will continue the advance with a weak screen deployed in the south flank.

Enemy Course of Action 2: Red suspects a trap and perceives that Blue is poised for an attack into their south flank if they continue the advance. Red turns south and occupies the chokepoints in preparation for passage of another Red follow-on division from a subsequent echelon.

Enemy Course of Action 3: Red's perception is as in Course 2. Anticipating a trap, it moves north out of Blue X Corps sector.

The Decision Problem

During the friendly COA development process, student planners have to consider the merits of securing the chokepoints leading into the northern area of operations.

Securing them beforehand can facilitate future operations and prevent the enemy from occupying them as blocking positions. On the other hand, it can reveal Blue intention early and can divert the enemy out of the Corps sector.

Not securing the chokepoints has the reverse effect. Also, it makes it more likely for Red to proceed into the trap.

The planner constructs a decision tree, as shown in Figure 4, to represent and analyze the problem.[5] At the decision point, there are two alternatives: secure the chokepoints or portray weakness by maintaining the current hasty defense posture until time to commence the

attack. If Blue portrays weakness, planners assess that there is a 0.8 probability the Red will continue the advance into the trap. In this case, Blue can attack into their flank. On a scale of 0 to 10, planners judged that this outcome would score 8. On the other hand, there is a 0.2 chance that Red will set up a hasty defense at the chokepoints. Then, Blue will have to attack into hasty defenses. This less favorable outcome get a score of 4. If Blue chooses to secure the chokepoints, Red can adopt one of three actions with these corresponding probabilities:

1. A probability of 0.4 that Red will continue the advance, in which case Blue can execute a violent flank attack as a result of the secured chokepoints. This was judged the most desirable outcome with a score of 10.

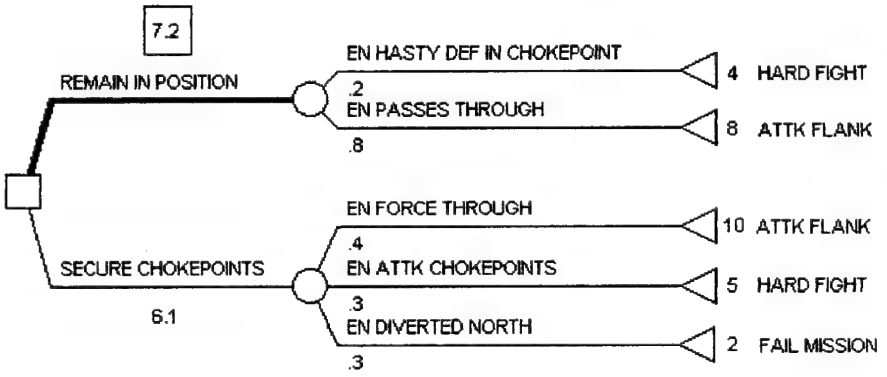


Figure 4. Decision Tree of Division Planning Vignette

2. A probability of 0.3 that Red will attack Blue's blocking positions. Blue has the advantage of fighting from defensive positions but loses initiative. Blue planners value this outcome at 5.

3. A probability of 0.3 that Red will divert to the north. Blue will fail to destroy the enemy. This outcome is valued at 2.

To evaluate the decision tree, the expected value of each COA is computed. For the Portray Weakness option, the expected value is 7.2 (that is, 0.2 x 4 + 0.8 x 8). The expected value of the Secure Chokepoint option is 6.1. Given these probability assessments of the enemy COA and value judgments about the worth of the outcomes, the better COA is the Portray Weakness option (with an expected value of 7.2).

Sensitivity Analysis

The better COA is to remain in a hasty defense to portray weakness. The question is, what has to change to make the other COA, Secure Chokepoint, the better decision.

First, we review the value judgments about the outcomes. The question is whether the values assigned to the outcomes are consistent with the commander's intent. Mistakes in the value judgments will cause the analysis to be misleading. Although sensitivity analysis can deal with uncertainties in our own value judgments, it takes considerably longer time to do so. The resultant analysis will also involve so many "what ifs" that it tends to cloud the issues. The way around this is to get agreement for the value judgments of the outcomes from the commander or from his statement of intent.

In our scenario, the commander highly values attacking the enemy from the flank (score of 8). Further, he desires a flank attack that passes through the chokepoints with ease (score of 10). The commander attaches a lower value to a battle against enemy hasty defense

at the chokepoint (scores 4) but feels it is better, if this should be the case, that we fight from previously secured positions (score of 5). The worst outcome is causing the enemy to divert north from our sector (score of 2).

Conducting this analysis offers the planner a thorough grasp of the possible endstates. Having gained consensus for these value judgments, we will hold them constant throughout the remainder of the analysis.

Next, we look at the contributions to the expected value. One can see that the expected value is the sum of contributions from all chance events (enemy options). The task here is to find ways to weaken the "best" COA and improve the "poorer" COA within the limits of our assessment of the situation.

For the Portray Weakness COA, one contribution is 0.8 (0.2 x 4) from the branch where the enemy occupies the chokepoints. The other branch, in which the enemy continues west, gives the main contribution of 6.4 (0.8 x 8). The reason why this COA is nominally recommended is largely due to the high likelihood of catching Red on the flank. What if Red commander were more cautious and therefore less likely to continue west into our trap? If the probability of each option becomes now even (that is, 50-50 chance), the expected value becomes 6.0 (0.5 x 4 + 0.5 x 8). The decision will now be in favor of the other COA since this expected value is less than 6.1. We asked the G2 if an even chance between enemy options is plausible. The G2 said it is possible but given our understanding of Red doctrine, it is unlikely to be less. He thought it more likely for Red to continue west if they see the chokepoints are not occupied. To prevent a surprise Blue attack from the south flank, Red can hastily lay obstacles, set anti-tank (AT) traps, use a persistent chemical agent or choose a combination of these

to secure their south flank. Some conclusions of this part of the analysis were:

1. If we choose the Portray Weakness COA, we should try to foreclose the Red option to occupy the chokepoints and defend them.

2. If Red heads west, our attack into their flank must account for enemy reaction such as hasty obstacles, AT traps and a chemical attack.

For the Secure Chokepoint COA, we look at the contributions that will cause the expected value to be low. We note that the smallest is 0.6 (0.3 x 2). This is associated with the enemy being diverted out of the Blue Corps sector. Based on the commander's intent to destroy the enemy, this is the poorest outcome because we have failed in our mission. By this simple analysis, we have identified what appears to be the most critical failure mode at this stage. This is also the main factor that prevents us from securing the chokepoints. We conclude that Blue must do the utmost to foreclose the Enemy Diverted North option. If we manage to deny Red this option, the likelihood that Red will adopt one of the two remaining options will be higher. We will then attempt to force the enemy not to attack our positions at the chokepoints. This will be difficult if Red discovers our presence at the chokepoints. If we are discovered, the enemy is certain to engage us there. The expected value will thus be 5.0.[6] At this stage, the Secure Chokepoint COA is still poorer than the Portray Weakness COA (expected value of 7.2 with a possible worst value of 6.0). The question is what can we do to remain undiscovered. If Blue succeeds in remaining undiscovered in the chokepoint until the attack, the prize is the achievement of the best possible outcome (score of 10). Some conclusions from this part of the analysis were:

1. We must do the utmost to prevent Red from being diverted from our sector.

2. We must not be discovered in the chokepoints if we want to occupy them.

3. This COA has the potential of achieving the best outcome.

Insight

While drawing conclusions from the decision tree analysis, the planning staff gained insights that had not occurred to them earlier. The first was that the enemy can avoid battle by diverting north from our sector. This results in a request to the Corps to close the northward approach. A combination of aviation, long range artillery, rapid mining and surveillance assets will be concentrated there to prevent Red from moving north. This reorders the initial priority of attacking deeper enemy follow-on echelons at this stage. As a result, follow-on echelons will have to be dealt with later.

The next insight occurred as we tried to foreclose enemy options. We wanted to actively lure the enemy into the trap. Adopting one COA or the other would lead to less than satisfactory results. A better idea, obtained by examining the decision tree carefully, was to initially portray weakness by remaining in hasty defense locations. Initial enemy reconnaissance would report an open road to the west, Red's objective. As Red forces moved into our trap, an intense program of counter-reconnaissance and counterfire would attempt to remove their reconnaissance capability.[7] At the appropriate time, elements of the Blue force would secure the chokepoints. As Red forces entered the trap, the bulk of the Blue forces would then rapidly strike them on their flanks through secured chokepoints. Having arrived at this concept of operation, all combat elements (Battlefield Operating Systems) synchronize their support.

By decision tree analysis, it became clear to planners that the key to the success was to produce conditions that would create the best

chance of luring the enemy into the trap. Planners thus selected the most prudent COA under enemy uncertainty. They adopted the Portray Weakness COA with an attempt to blind the enemy. If successful, they would proceed to secure the chokepoints to facilitate operations. In this way, the decision tree analysis had yielded insights that in turn clarified what ought to be done.

Towards the Proposed Planning Methodology

The proposed planning methodology will be used during the wargame stage of planning. It will guide the thought process in the wargame and aid analysis of the plan as it is built. The major change to the flow of the wargame that decision tree-based methodology brings is to the planning sequence. With the new methodology, planners will complete wargaming of all branches of enemy options before proceeding to the next event. The main wargame recording method will be the construction of the decision tree.

The basic idea of the proposed planning methodology is to model a COA as a series of battlefield decisions that roughly corresponds to our own decision-cycle. It is thus an extension of the one-decision COA that was considered in the division planning vignette.

Modeling the COA as a series of battlefield decision is also consistent with the action-reaction-counteraction paradigm that is adopted for the wargame. This will facilitate the flow of the wargame. Figure 5 shows the decision tree construct to represent a COA with several decision cycles.

For the decision tree to be useful, the number of branches on it should be kept manageable. The planner has to decide what the essential factors are and how much detail to usefully include. In the next chapter, we will refine this planning methodology and apply it to a brigade planning scenario.

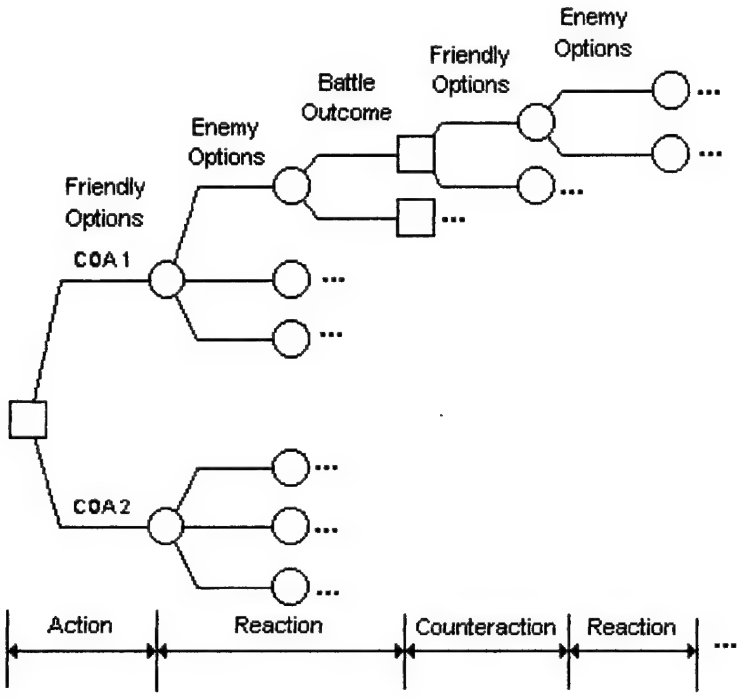


Figure 5. Decision Tree Construct with Several Decision Cycles

Endnotes

[1] A simple decision problem consists of one decision. In this tactical scenario, the courses of action are completely specified by one decision: to secure the chokepoints or not.

[2] Ronald A. Howard, "The Party Problem," (1991).

[3] The planning exercise was part of tactical instruction during C320 Corps and Division Combat Operation of the CGSOC: Exercise DEPUTY DAWG. Students play the division staff of the 25th Armor Division which is part of the U.S. X Corps.

[4] A chokepoint is a narrow route of movement that is restricted on either side by terrain. Therefore, a small military force can effectively control movement through it.

[5] The decision tree was actually used during the planning exercise. Having understood the problem, the author constructed the decision tree within 10 minutes.

[6] We reasoned that if Blue has somehow induced Red not to be diverted from the sector and if the enemy discovers our chokepoint positions, the enemy will attack our position (probability of 1). The expected value in this case is 5.0 (1 x 5.0).

[7] Counter-reconnaissance means lethal and non-lethal attacks to reduce the enemy's capability to gather information and to produce intelligence. Counterfire are fires and electronic attacks intended to destroy enemy's indirect fire systems.

CHAPTER FOUR

CASE STUDY ANALYSIS

> There have been hopes that a mathematical theory employed in conjunction with a quantitative concept of [military] worth will tend to eliminate bias and emotional influences from our decisions. These hopes appear largely unfounded.[1]
>
> Haywood

Introduction

In this chapter, we will apply the proposed planning methodology to a brigade defense mission. The scenario in OPLAN WHITE is used because it is familiar to many U.S. Army officers.[2] The U.S. Army Command and General Staff College (CGSC) uses this scenario to teach the foundation tactics course, C310 Fundamentals of Combat Operations. We also chose this scenario because CGSC provides the school's solution to the tactical problem. Obviously, this solution is based on the current planning methodology. Thus, we can use it as an illustration of the product of the current approach.

A brief description of OPLAN WHITE will be followed by the application of the proposed planning methodology to plan a brigade mission. The two brigade courses of action (COAs) developed in OPLAN WHITE will be analyzed using the decision tree construct.

The new methodology will then be evaluated against the list of attributes of an ideal planning methodology developed in Chapter Two. We will assess its efficacy critically and draw some conclusions.

OPLAN WHITE

Introduction

OPLAN WHITE is the Operations Plan (OPLAN) of the notional 55th Mechanized Division to defeat the fictitious 2d Nebraskii Army. The battle is set in the vicinity of Fort Leavenworth, Kansas. The Nebraskii Army attacks from the north. It adopted tactics and organization similar to that of the former Soviet Union.

For this exercise, we assume the role of the planning staff of the 3rd Brigade of the 55th Mechanized Division.

General Enemy Situation

Facing 55th Mechanized Division is the 2d Nebraskii Army with two Motorized Rifle Divisions (MRDs), one Tank Division (TD) and one Independent Motorized Brigade (IMR Bde).

Our intelligence assessment indicated that the 2d Army is organized as follows:

The first echelon consists of two MRDs, which will be attacking abreast from north, with the mission of destroying the defending U.S. Army brigades. The western MRD, the 3d MRD, will be the main effort. The eastern MRD, the 9th MRD, will be the supporting effort.

The second echelon consists of one TD, the 2d TD. Depending on which first echelon MRD has more success, this TD will pass through that zone and break out towards the Kansas River. Its immediate objective is to cross the river and defeat U.S. forces in that vicinity. Its subsequent mission is to turn east to link up with the Nebraskii 1st Army, thus completing the encirclement of Kansas City, their ultimate military objective. The 42d IMR Bde is the 2d Army reserve.

The sketch of the general enemy situation is show in Figure 6. The complete intelligence estimate can be found in the Advance Book that accompanies the C310 course.[3]

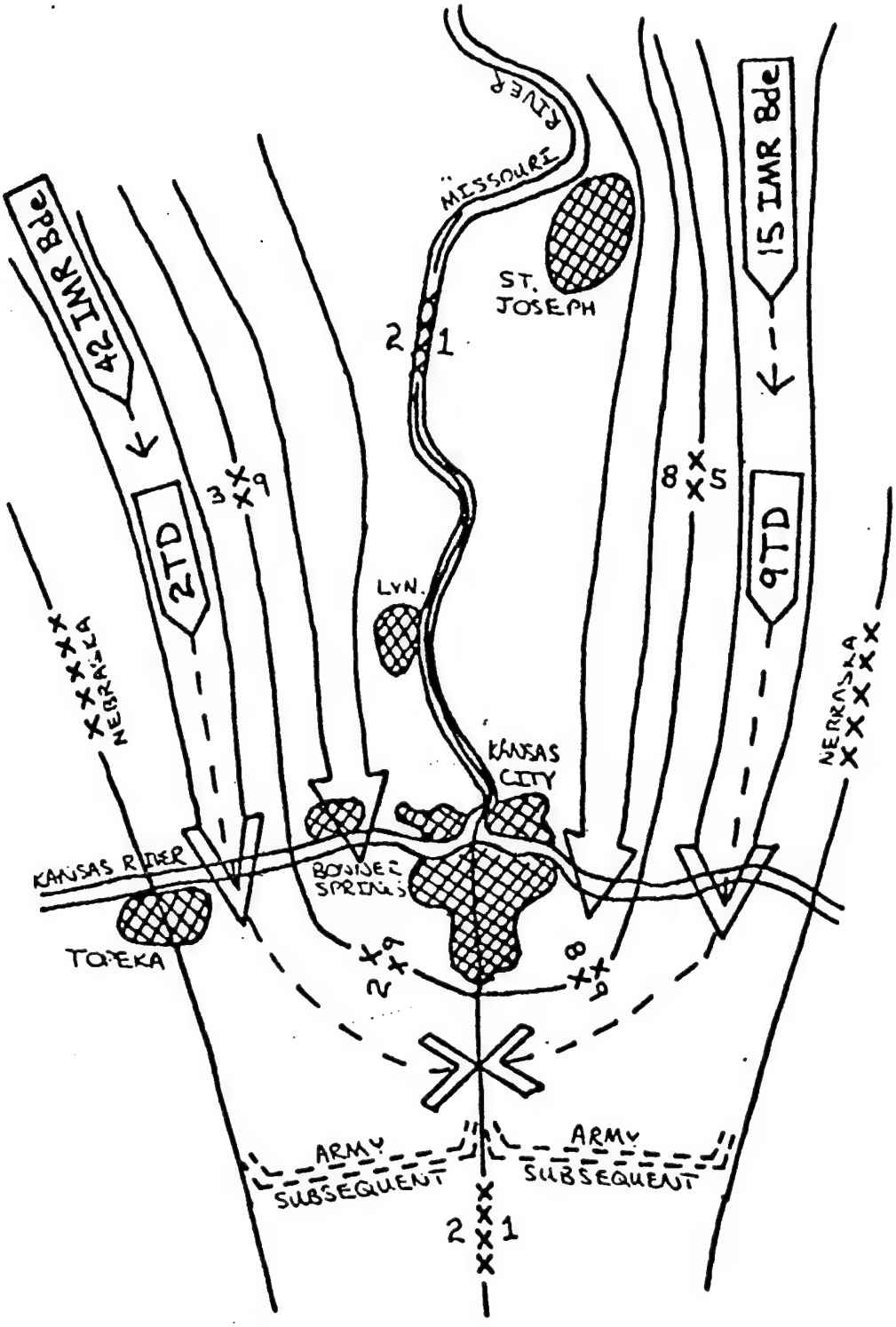


Figure 6. Sketch of the General Enemy Situation

55th Mechanized Division OPLAN

In OPLAN WHITE, the 55th Mechanized Division will defend its sector well forward (north) of Kansas River. The division commander intends to mount an area defense forward of a line designated as Phase Line BLUE (PL BLUE).[1] The sketch of the division defense plan is shown in Figure 7. After accepting battle handover from the Corps' Armored Cavalry Regiment, the division's aviation brigade will conduct guard

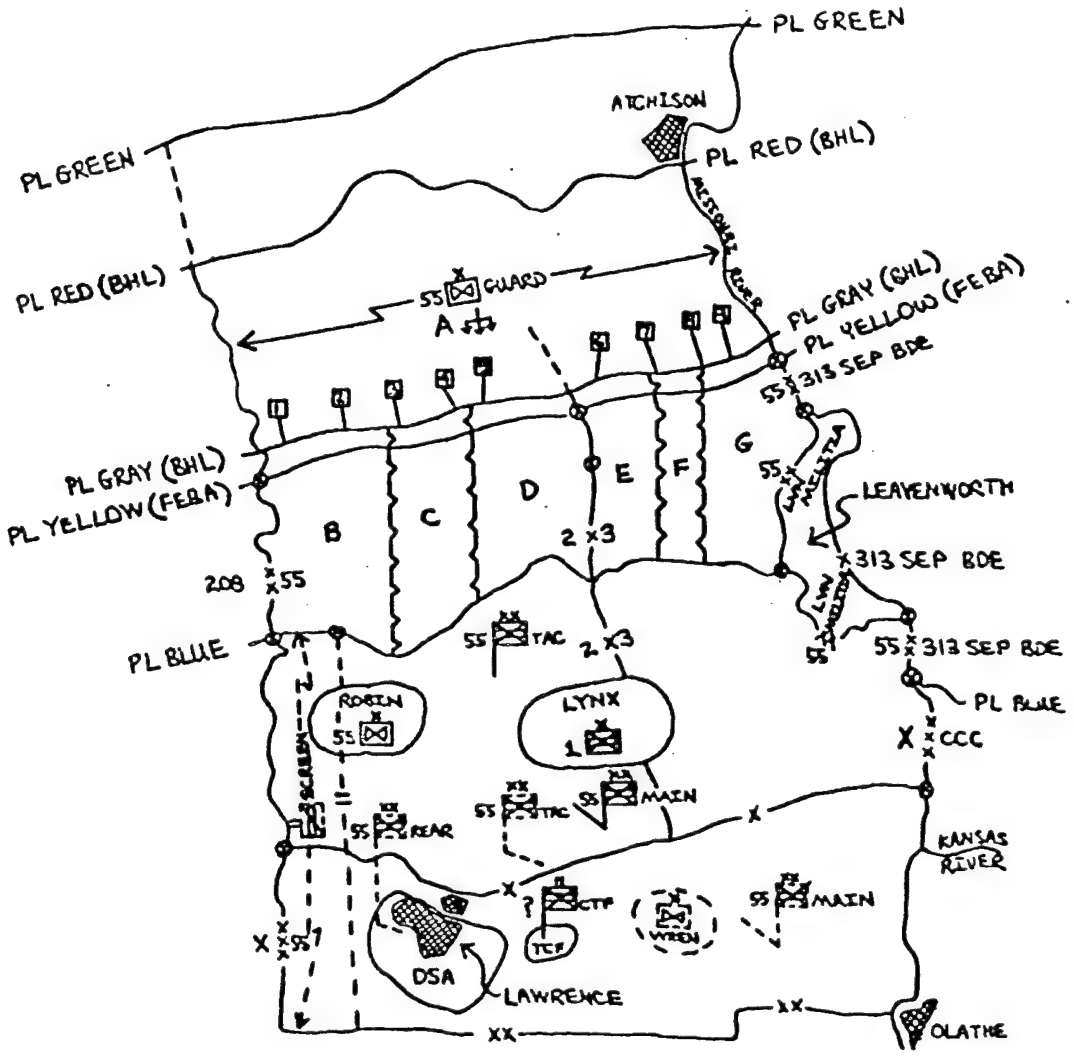


Figure 7. Sketch of the 55th Mechanized Division's Defense Plan

operations north of the main defense area. The 2d Brigade and 3d Brigade defend abreast in the eastern and western sectors respectively. The 2d Brigade is the division's main effort. 1st Brigade, the division's reserve, occupies Assembly Area LYNX and prepares to counterattack Nebraskii forces penetrating PL BLUE. The division's deep operations will delay and disrupt follow-on forces so that the enemy can only introduce their forces into battle in a piecemeal fashion.

The division has two contingency plans (CONPLAN) to prevent enemy penetration of PL BLUE. The first requires the 1st Brigade to counterattack into the 2d Brigade sector. The second, named CONPLAN TOP HAT, guards against the possibility of the enemy shifting its main effort into 3d Brigade sector.[5] CONPLAN TOP HAT will be activated if the 3d Brigade is weakened considerably in the main defense battle and if there are indications that the first echelon regiment (5th TR) of the second echelon division (2d TD) is attacking into 3d Brigade sector. The 1st Brigade will pass through the 3d Brigade sector and flank the approaching TR from the west.

3d Brigade's Mission

Assets Available

The 3d Brigade's mission is to defend the eastern sector, allowing no penetration of enemy forces south of PL BLUE. This is the supporting effort of the division. To accomplish this, the division has given it four mechanized infantry companies, four tank companies and one armored vehicle-mounted anti-tank weapons company (BTV company). These forces can be tailored into two battalion-task force commands. Additionally, the brigade will receive command of TF 4-77, a battalion-task force consisting of two mechanized infantry companies, one tank company and one BTV company, upon the completion of the divisional guard battle. The brigade anticipates that TF 4-77 will be reduced to 65%

strength but can be restored to at least 70% combat effectiveness in a few hours.

Terrain

The brigade area of operation (AO) is bounded on the east by the Missouri River; on the south by the Kansas River; on the west by Stranger's Creek and on the north by the Battle Handover Line traced by Phase Line (PL) GRAY. PL BLUE, which runs east to west across our AO approximately divides it into two halves. South of PL BLUE, the AO is open and flat. Consequently, the defense battle will take place in more defensible terrain, north of PL BLUE. This area can be categorized into three sub-areas in terms of terrain characteristics: west, central and east. In the west, we have broken terrain. Tributaries to Stranger's Creek cut deep ravines into the ground which restrict north-south movement. The central area is open and almost flat. This is the high-speed approach for massed armor. The terrain in the east is hilly with patches of wooded areas. It is thus relatively more restrictive to massed armor. All three sub-areas are cultivated but in our timeframe, the crops are harvested. This improves intervisibility. The weather has been dry and so the ground can support armor movement throughout the AO without problems. Coupled with the fact that the area is well-served by roads and tracks, the AO has excellent armor maneuvering potential.

Enemy

The enemy facing the 3d Brigade is the 9th MRD. The division estimates that the Corps covering force and the divisional guard battles can destroy the first echelon regiments of this MRD. Upon battle handover from the divisional guard force, the 3d Brigade will meet the second echelon regiments (one tank and one motorized rifle regiment) of

the 9th MRD and the Independent Tank Battalion (ITB).[6] These are the specific enemy forces it has to face.

If the enemy perceives that the attack in the 3d Brigade sector is going well, he can shift his first echelon tank regiment of the second echelon tank division into the sector. This is the contingency for which the 3d Brigade will prepare.

Enemy Courses of Action

Planners for the 3d Brigade arrived at two enemy courses of action (enemy COAs), as follows:

Enemy COA 1. The enemy attacks with two regiments abreast; the main effort in the west and a supporting effort in the east. Their mission is to rupture the defense and open a gap through which the ITB can pass. They will then continue to destroy the defending brigade. The ITB will attempt to secure a crossing across the Kansas River to facilitate future operations.

Enemy COA 2. The enemy attacks with two regiments abreast; the main effort in the east and a supporting effort in the west. Similar to COA 1, their mission is to rupture the defense and open a gap through which the ITB can pass. They will then continue to destroy the defending brigade.

Common to Both Enemy COAs. Having defeated defending forces in their attack zone, the enemy will attempt to continue their advance south. If, however, the defending force in the adjacent zone is still holding ground, they have the option of executing a flank attack to destroy the resistance. For example, if the regiment in the west has penetrated forward defenses, it can either continue its advance south or hook east to destroy the remaining defending forces (from the flank) in the adjacent regiment's attack zone.

If the penetration of the defenses is successful and if the enemy perceives an imminent collapse of the forward defense, the second echelon tank division can be channeled through the breach. The enemy is likely to lead with a tank regiment (possibly the 5th TR). This regiment's mission is to secure a bridgehead on the south bank of the Kansas River. The rest of the second echelon tank division can pass through the same breach in the 3d Brigade sector, cross the river and continue to encircle Kansas City.

3d Brigade's Courses of Action

3d Bde planners formulated concepts for two courses of action (COA) as follows (see Figures 8 and 9):[7]

COA 1. On order, the 3d Brigade defends in sector with two battalion-task forces abreast to destroy second echelon regiments and the ITB of the first echelon division and defeat one regiment of the second echelon division forward of PL BLUE. A balanced task force is the main effort in the west, with a mechanized infantry-heavy task force as the supporting effort in the east. The Brigade accepts battle handover from divisional guard force at PL GRAY. Main Battle Area (MBA) task forces destroy attacking regiments and the ITB of the first echelon division forward of PL BLUE. The supporting effort prevents enemy access to the town of LEAVENWORTH. The Brigade's priorities for deep operations are to delay and disrupt the commitment of the ITB and then to delay and disrupt the commitment of the regiment from the second echelon division. MBA task forces are responsible for their own flank security. Initially, one tank-heavy company team is the brigade reserve in assembly area (AA) RAT. On completion of rearward passage, TF 4-77 (a mechanized infantry-heavy task force) reverts to brigade control, moves to AA RAT, reorganizes and on order receives attachment of the tank-heavy company team and becomes the brigade reserve. Priority of

commitment of the reserve is to block penetration of PL BLUE in the western sector. The brigade reserve or the 55th Mechanized Division provides Level III response in the brigade rear area.[9] After defeating the regiment from the second echelon division, the Brigade reestablishes defenses between PL BLUE and PL ZULU and prepares to attack in zone to complete the destruction of the remaining enemy forces and to reestablish the border.

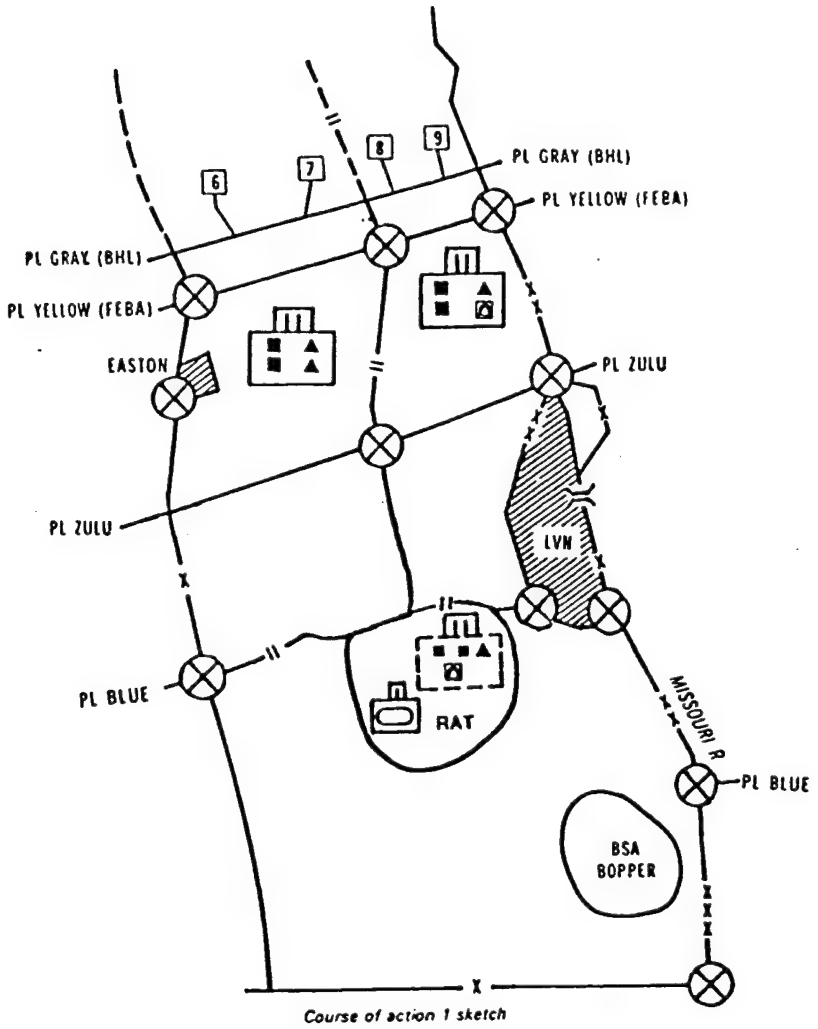


Figure 8. Course of Action 1

COA 2. On order, the 3d Brigade defends in sector with two battalion-task forces abreast to destroy second echelon regiments and the ITB of the first echelon division and defeat one regiment of the second echelon division forward of PL BLUE. MBA units accepts battle handover and assist the rearward passage of divisional guard force elements at PL GRAY. A tank-heavy task force in the west is the main effort and defends in sector, destroying one regiment and the ITB from the first echelon division. A mechanized infantry-heavy task force in the east is the supporting effort and defends in sector, destroying one regiment from the first echelon division. Main and supporting efforts shape the battlefield by preventing enemy forces from penetrating PL SILVER, setting the conditions for a brigade counterattack by a task force. MBA task forces are responsible for their own flank security. The Brigade's priorities for deep operations are to delay and disrupt the commitment of the ITB and then to delay and disrupt the commitment of the regiment of the second echelon division. A mechanized infantry company team is the brigade reserve in AA BOLD; its priority of commitment is to the main effort. The brigade reserve or the 55th Mechanized Division provides Level III response in the brigade rear area. On completion of rearward passage, TF 4-77 reverts to brigade control, moves to AA FIX, reorganizes and on order, becomes the brigade counterattack force. On order, TF 4-77 moves along axis STRIKE and counterattacks to defeat the regiment from the second echelon division in the vicinity of objective MELEE, preventing penetration of PL BLUE. The Brigade reestablishes a coherent defense between PL SILVER and PL YELLOW, continues to defend sector and prepares to transition to the offense to complete the destruction of the remaining enemy forces.

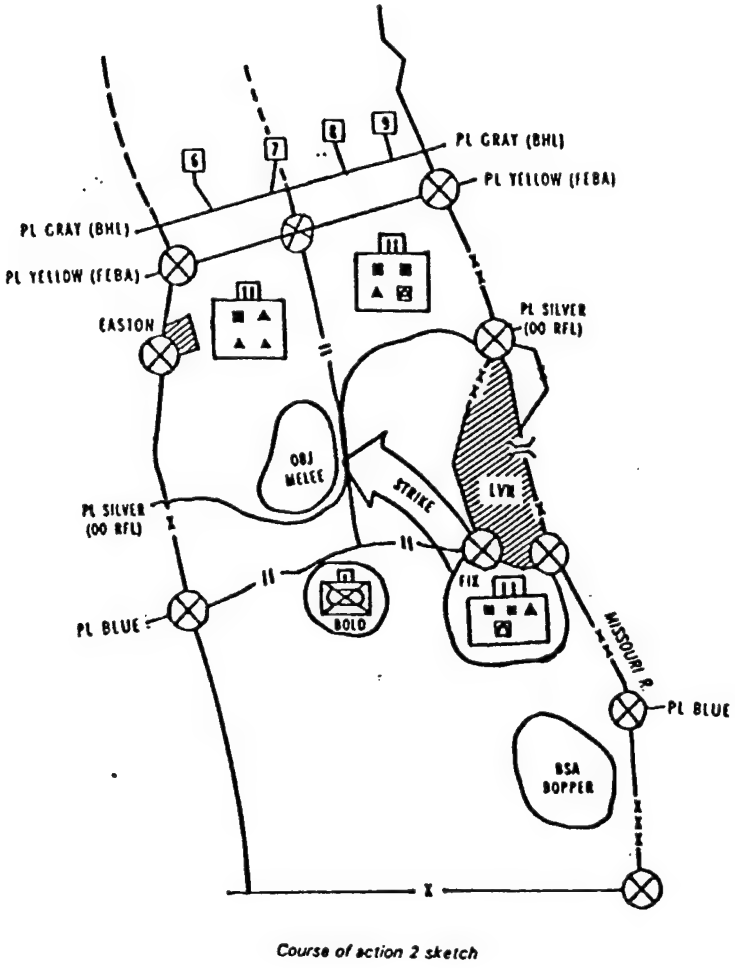


Figure 9. Course of Action 2

Courses of Action Analysis

Introduction

Before we apply the proposed planning methodology to COA analysis, it is worthwhile to set it in context. The methodology is applied during the wargame. The decision tree that will be presented is constructed as the wargame proceeds. Enemy options and friendly options at each decision point and chance events are assessed as the situation develops in the wargame. Military judgments (subjective inputs) such as

probabilities of occurrence of enemy actions and the outcomes of events represent the "feel" planners get from wargaming the scenario. The sequence of construction of the decision tree dictates the sequence of wargaming.

Wargaming Sequence

Starting with the first critical event of the wargame, the general sequence is to complete one friendly COA before starting the next. After planners have wargamed all friendly COAs, they can move on to the next critical event. The reason for this approach is that when attention is focused on the issues within the same event, it will facilitate the comparison of COAs.

If time is a constraint, planners can wargame the most promising COA first in its entirety (that is, wargame all critical events with one COA first.) This scheme allows them to complete a plan in the time available.

Using the action-reaction-counteraction cycle, planners will wargame the first branch to completion and then start on the next branch. Within each branch, planners will incorporate all enemy options given the situation at that point in time, then formulate friendly actions to counter them. Our actions may precipitate yet more possible enemy actions. This in turn requires the planner to formulate another set of counteractions. This process is followed until the end of the critical event or when the enemy has been defeated. This wargaming sequence will be demonstrated using OPLAN WHITE as an example.

Suggested Steps for the Proposed Planning Methodology

The following are the suggested steps for the proposed planning methodology:

1. Identify the critical events to wargame.

2. Identify the similarities and differences in the friendly COAs within the critical event. Common parts of the COAs need only be wargamed once.

3. Identify the main elements of uncertainty posed by the enemy.

4. Establish a preliminary scale of values (or military worth) of possible outcomes. This step encourages the planner to think about the endstates of the critical event and reinforces the planner's understanding of the commander's intent. This preliminary value scale serves as a guide for the planner to maintain consistency in assigning numbers to the decision tree that represent relative desirability of the outcomes.

5. Start the wargame, following the wargaming sequence prescribed above. To record the wargame, planners construct the first branch of the decision tree. As the wargame yields results, planners fill in the probabilities of occurrence of enemy options and record the reasons for their assignment. Similarly, planners fill in the values of the outcomes.

6. Record insights as they occur during the wargame. Insights are a rare and perishable commodity. Whether applicable or not, they serve as mental cues which may be useful later.

7. Perform preliminary sensitivity analysis of the decision tree when the first COA wargame is completed. The purposes are to understand the dynamics of the battle, to see where critical points in the battle occur and to identify what actions are required to foreclose enemy options that can bring unfavorable outcomes.

8. Go to the next critical event using the same COA if time is a constraint. Otherwise, wargame the same critical event using the next COA.

9. Perform a sensitivity analysis of the decision tree after all COAs are wargamed. The main purpose is to compare the COAs. We will also find, if possible, the best "composite" COA from all those that are considered. The insights generated during this analysis can probably yield ideas for deception and supporting efforts from other combat elements.

10. Synchronize efforts of the combat elements in each COA.

11. Repeat from step 2 onwards for next critical event.

We will now demonstrate the use of the proposed planning methodology by applying it to the 3d Brigade plan of OPLAN WHITE.

Identify Critical Events

The 3d Brigade plan envisions a defense in two phases. The first involves defense against the second echelon regiments of first echelon division and the ITB. In the second phase, 3d Brigade defends against a tank regiment from the second echelon division. If the defense goes awry in the first phase and the 3d Brigade is overrun, it is possible that the second phase be carried out by the 55th Mechanized Division's reserve (1st Brigade) by executing Contingency Plan TOP HAT. Thus, we identify the whole first phase as one critical event to wargame and the second phase as the other. For this thesis, we will demonstrate the use of the proposed planning methodology with the first critical event, the initial defense.

Identify Similarities and Differences between COAs

In both COA 1 and 2, the 3d Brigade will defend with two battalion-task forces (TFs) abreast, with the main effort in the western sector (left TF or LTF), the supporting effort in the eastern sector (right TF or RTF) and with a company team as the initial reserve. Only the composition of the LTF and the initial reserve are different. In

COA 1, the LTF consists of two tank and two mechanized infantry companies, while the reserve is a tank company (LTF = 2T/2M; Res = T). In COA 2, the LTF consists of three tank companies and one mechanized infantry company, while the reserve is a mechanized infantry company (LTF = 3T/M; Res = M). In both COAs, the RTF consists of two mechanized infantry, one tank and one BTV companies (RTF = 2M/T/BTV). Also, coming under command of the 3d Brigade after the divisional guard force battle is TF 4-77, a task force with two mechanized infantry, one tank and one BTV companies (TF 4-77 = 2M/T/BTV).

Identify Main Element of Uncertainty Posed by the Enemy

The main element of enemy uncertainty is whether they will attack with their main effort in the east or the west. Although the terrain dictates that the enemy tank regiment is best used in the west and the motorized rifle regiment is best used in the east, it is uncertain which effort they will weigh with the preponderance of their substantial artillery firepower. The location of the enemy main effort can significantly affect the way we deploy for defense.

Establish Scale of Values or Military Worth

The planner should list the various endstates, ranks them in order of preference and assigns a value to each. If the problem is simple, the planner will have no difficulty establishing the value scale. If the problem is more complex, the following is a suggested method of constructing a consistent value scale.

In establishing the relative desirability of outcomes, we considered a hierarchy of goals. In order of importance, the levels are:

1. The extent of damage inflicted on the enemy.

2. The place on the battlefield at which we inflict the damage on the enemy.

3. The involvement of reserves to inflict the damage.

We will explain each level in turn.

First, we prefer destruction of the enemy to just its defeat. Destruction means physical destruction of the enemy's combat power such as tanks, artillery pieces and personnel. Defeat means the elimination of the enemy's ability to carry out its intended mission. Defeating the enemy will probably require the physical destruction of a portion of his force. However, this falls short of total destruction. In an enemy attack, we have defeated it if it is forced to retire from the battlefield or to take up hasty defense positions.

The next level of preference is the place at which we have stopped the enemy. This comes from our perception that the enemy is less likely to commit its second echelon forces (5th TR) into our sector if we defeat them forward of our position. If we allow penetration, whether deliberately or not, the enemy commander may perceive weakness in the defense and commit more forces into our sector in the hope of creating a breach. Hence, we value an outcome which stops the enemy forward rather than inside our defense area.

Third, we prefer an outcome that will defeat the enemy without the commitment of our reserve to one that does. The commitment of reserve entails additional risks. It is more desirable, in our search for a good COA, if we can engineer a deployment that lessens the number of "moving parts."

Given these considerations, a preliminary scale of values of the outcomes, on a scale between 0 (worst) and 10 (best) can be constructed as follows:

1. Destroy the enemy forward of the defense area without commitment of reserve - 10.

2. Destroy the enemy forward of the defense area with commitment of reserve - 10.

3. Destroy the enemy within the defense area without commitment of reserve - 9 or 10.

4. Defeat the enemy forward of the defense area without commitment of reserve - 9 or 10.

5. Destroy the enemy within the defense area with commitment of reserve - 7 or 8.

6. Defeat the enemy forward of the defense area with commitment of reserves - 6 or 7.

7. Defeat the enemy within the defense area without commitment of reserve - 7.

8. Defeat the enemy within the defense area with commitment of reserve - 5 or 6.

On the other end of the spectrum, we have to rank poor outcomes. If we should face a rupture of the defenses, we will attach higher value to an outcome that limits a penetration and allows the commitment of a division counterattack than to one in which the enemy breaks through PL BLUE. We append two more endstates to the list as follows:

9. Block enemy penetration at PL BLUE after forward defense positions overrun - 4.

10. Defense fails and the enemy breaks through PL BLUE - 0.

This scale is intended as a guide for consistency and need not be applied too strictly. Planners may have other reasons why certain outcomes do not adhere to this preliminary scale (for example, one may accept a marginally poorer outcome if, say, it permits a gain of positional advantage as a consequence). More importantly, this exercise makes planners think about the possible outcomes of the battle and their relation to the mission and commander's intent.

Start the Wargame and Construct the Decision Tree

Framework

In the critical event we consider (the initial defense), the essence of the tactical problem is to compare the outcome of COAs 1 and 2 under the uncertainty of the location of enemy main effort. The immediate outcomes are whether the LTF and RTF sectors can hold or break against enemy attack. Thus, there are four possible combinations of immediate outcomes as shown in the decision tree depicted in Figure 10.

The enemy can and will gather intelligence on our disposition. This will affect their choice as to where the main attack should go. We estimated that there is a greater chance that the enemy will conduct the main attack in the west if they believe our LTF is weak (COA 1). To reflect this, we assign a probability of 0.7 to this branch. On the other hand, if the enemy discovers a strong LTF (COA 2), they are less likely to put in the main attack in the west. We assign a 0.5 chance to this branch, as shown in Figure 10.

This is all one can reasonably judge now. The assignment of probabilities to the immediate outcomes (that is, to various combinations of LTF and RTF holding or breaking) should be done later when the wargame yields some basis for estimation.

We will now wargame, in turn, what we must do when each outcome occurs, starting with the decision marked "A."

COA 1

Branch A

We recall the starting conditions at our decision point marked "A" (see Figures 10 and 11). We have deployed a balanced task force as the LTF (2M/2T), a mechanized infantry-heavy task force as the RTF (2M/T/BTV) and a tank company in reserve. TF 4-77 has reverted to

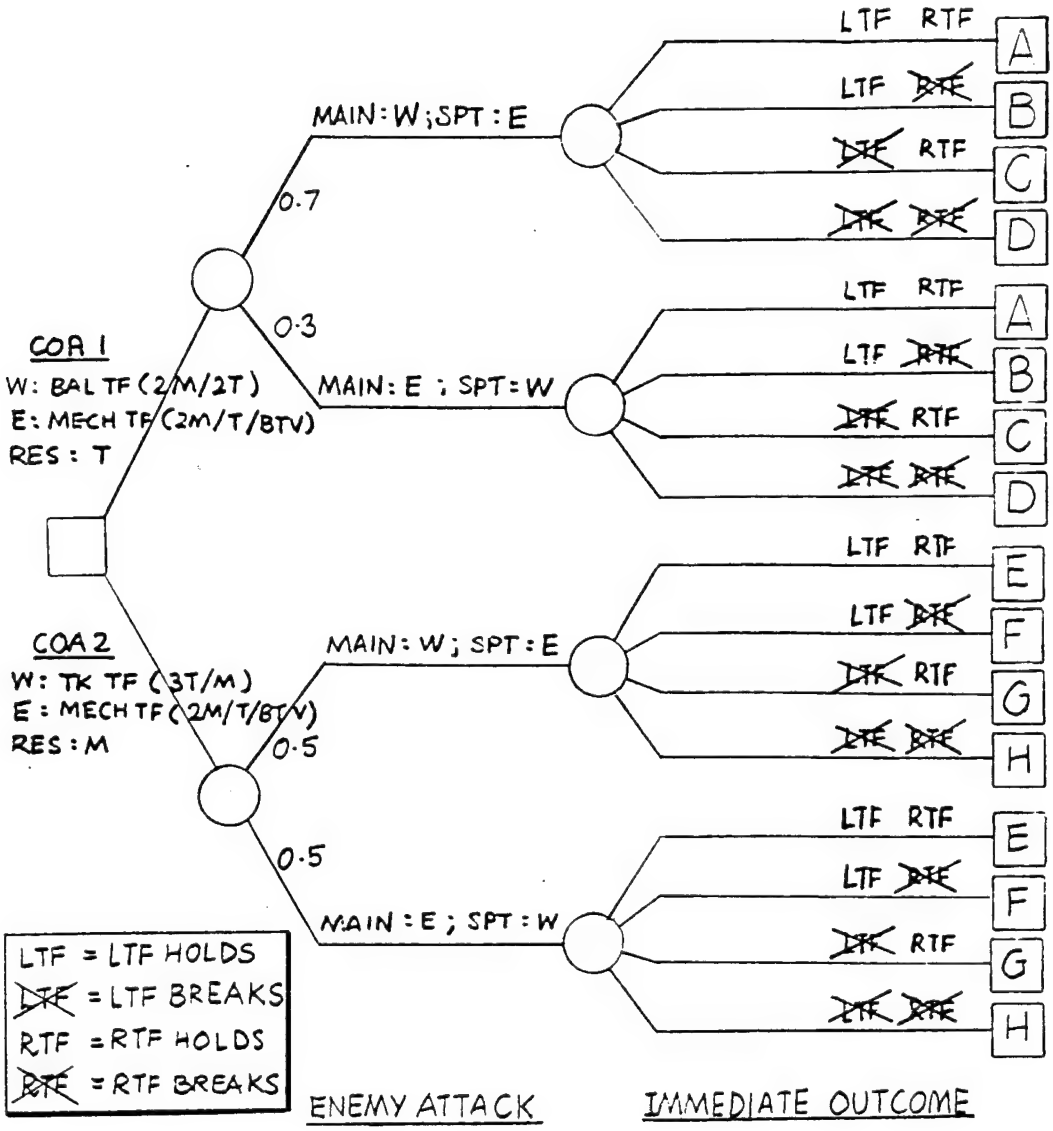


Figure 10. Framework of the Decision Tree

Brigade command at 65% strength and is in the process of reorganization. It would not be available for the initial fight. The enemy has chosen to commit its main attack in the west and a supporting attack in the east. On branch A, we have a favorable outcome with both LTF and RTF defenses holding. The attacking regiments are defeated forward of the defense area. The LTF is significantly weakened in the tank battle in open country. The next event in the wargame is the ITB attempting to break through the weakened sector.

We have two options: To continue to fight as deployed or to commit the tank company reserve by reinforcing the LTF. In the latter case, we will have to call on TF 4-77 before the have a chance to reorganize fully if there is a contingency. When the ITB attacks, we envision two possible outcomes: It will either be defeated forward of friendly defense area or break through the forward defenses. In case the ITB has broken through, we will launch TF 4-77, whether reorganized or not, to deal with it. Figure 11 shows all branches associated with COA 1.

On branch A, we have assigned probabilities and the evaluated the outcomes. Rolling back the tree, we see that both friendly actions have about equal merit. At this point, our aim is not to choose one action or the other but to recognize the options we have and to plan for their employment. From the analysis, we saw that the tank company reserve may be committed as follows:

1. Reinforce LTF or RTF sector. Planners should therefore identify the routes to take and co-ordination measures necessary for link-up.

2. Counterattack, as part of TF 4-77, elements of the ITB that have penetrated the forward defense area. Planner should consider where the counterattack will occur.

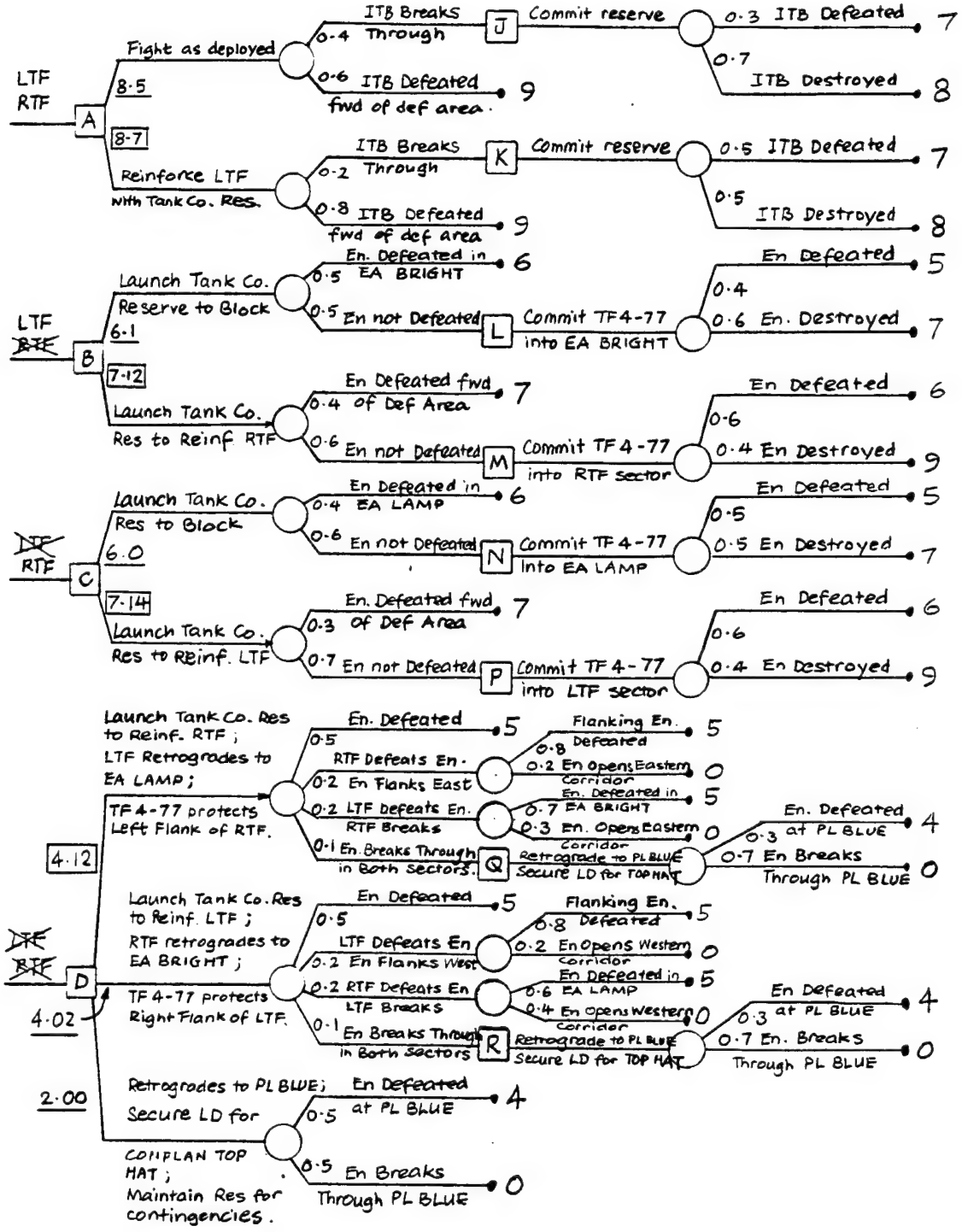


Figure 11. Decision Tree - Branches A to D

Branch B

On this branch, the LTF sector holds while the RTF sector is vulnerable to penetration. Results of the wargame suggest that up to a motorized rifle battalion and the ITB can break through. We have two principal options: Launch the tank company reserve to block the penetration or reinforce the RTF.

As we wargamed the first option, we saw a need to plan for an engagement area (EA BRIGHT) to defeat or destroy enemy forces that have penetrated the defense area. There is also a need to prepare fighting positions for the reserve force so they can contain the enemy in the engagement area north of the positions. We also realized the need to reconstitute another reserve once the tank company has been committed. TF 4-77 may have to react to contingencies before they have been fully reorganized.

For the option that requires reinforcement of the RTF, the main problem is timing. Planners have to identify the indicators of imminent collapse of the RTF sector so that launch of the reserve can be well-timed. Although the reinforcement option is difficult to execute well, it holds promise of defeating the enemy forward of the defense area, an outcome that is preferred to a penetration.

From the Branch B example, one can see how planners can gain understanding of the tactical problem when it is broken down into parts and analyzed using a decision tree.

Branch C

Branch C is similar to Branch B in terms of options available. In this case, the engagement area (EA LAMP) and prepared fighting positions will be placed astride the high-speed avenue of approach. Compared to Branch B, we have a lower chance of stopping an enemy penetration in the LTF sector because of the less defensible terrain.

Branch D

On this branch, we plan for the worst case. We are faced with the imminent collapse of the both sectors. Up to a regiment-sized force has broken through. We have three options:

1. Reinforce the RTF with the tank company reserve, let the LTF fight a retrograde battle and occupy block positions south of EA LAMP with TF 4-77 taking up positions between the RTF and new position of the LTF to protect the left flank of the RTF.

2. Reinforce the LTF with the tank company reserve, let the RTF fight a retrograde battle and occupy block positions south of EA BRIGHT with TF 4-77 taking up positions between the LTF and new position of the RTF to protect the right flank of the LTF.

3. Let the LTF and RTF fight retrograde battles to PL BLUE while securing the line of departure for the 1st Brigade to execute CONPLAN TOP HAT (division counterattack plan).

On this branch, it is evident that prepared fighting positions in depth and engagement areas BRIGHT and LAMP are important. Planners can also see the danger of an enemy flank attack into the adjacent sector, for example, in the case where enemy breaks through in the LTF sector and hooks east to destroy the RTF from the flank. To counter the hook, TF 4-77 needs to take up position to protect the left flank of the RTF.

Another possible outcome is that the RTF fails to defeat the enemy despite reinforcement of the reserve tank company. Here, the plan is for the RTF to fight a retrograde battle to positions south of EA BRIGHT, in the process drawing the enemy into EA BRIGHT. TF 4-77 will then attack into the west flank of the enemy trapped in EA BRIGHT. From the analysis, planners also see that the mirror-image scenario can happen. The enemy can break through in the RTF sector instead.

Cognizant of all the possible ways that TF 4-77 can be committed, planners then position TF 4-77 and synchronize its movement to react to possible contingencies. This is the advantage of what we call working across the enemy-option domain. Planners can look at all possible enemy options at once and look for a solution to counter all of them. Using the decision tree construct to order the sequence of wargaming allows planners to gain insight into the problem readily and determine what has to be done.

Preliminary Conclusions after Analysis of COA 1

The preliminary conclusions after analyzing COA 1 are as follows:

1. There is a need to prepare two sets of fighting positions for the tank company reserve in the depth of the brigade defense area: one set of positions to the rear of the RTF sector and one to the rear of the LTF sector. To defeat the enemy forward of these fighting positions, engagement areas BRIGHT (in the east) and LAMP (in the west) will be established.

2. It appears that planners prefer to use the tank company reserve to reinforce forward defense sectors rather than to use it to fight in a depth position. This reflects the preference to engage the enemy forward of the defense area. Planners perceive that the enemy second echelon division is less likely to be channeled into the brigade sector when no penetration occurs. The key problem, therefore, is to determine the correct time to launch the reserve.

3. Due to the need to reorganize TF 4-77, the tank company reserve will most likely be launched first.

4. TF 4-77 is an important element in the brigade's defense plan. It should be positioned to ensure its survivability and its ability to react to contingencies. We envision that TF 4-77 will occupy

an area in the brigade's rear for reorganization, only to be called forward to a position in the center of the brigade's sector on order.

COA 2

For the critical event that we are wargaming, the only differences between COA 1 and COA 2 are the following:

1. The LTF is now a tank-heavy task force with three tank and one mechanized companies (3T/M).

2. The reserve is a mechanized company instead of a tank company.

3. The names of the engagement areas are changed to prevent confusion. EA DARK and EA SPOT are established in the east and west respectively.

The rest of the details remain the same.

The main branches that represents COA 2 are marked "E", "F", "G" and "H." Figure 12 shows all branches associated with COA 2. Since the position and composition of forces are largely similar to those in COA 1, friendly actions, the enemy reactions and our counteractions are similar. The values we attached to the outcomes under similar circumstances are logically the same. The difference lies in our assessment of the relative likelihoods of the outcomes. In the following description of the branches, we will cover the main differences and provide supporting rationale.

Branch E

The situation on branch E corresponds to that on branch A. The branches are identical because we think the differences between COA 1 and COA 2 will not change the results significantly.

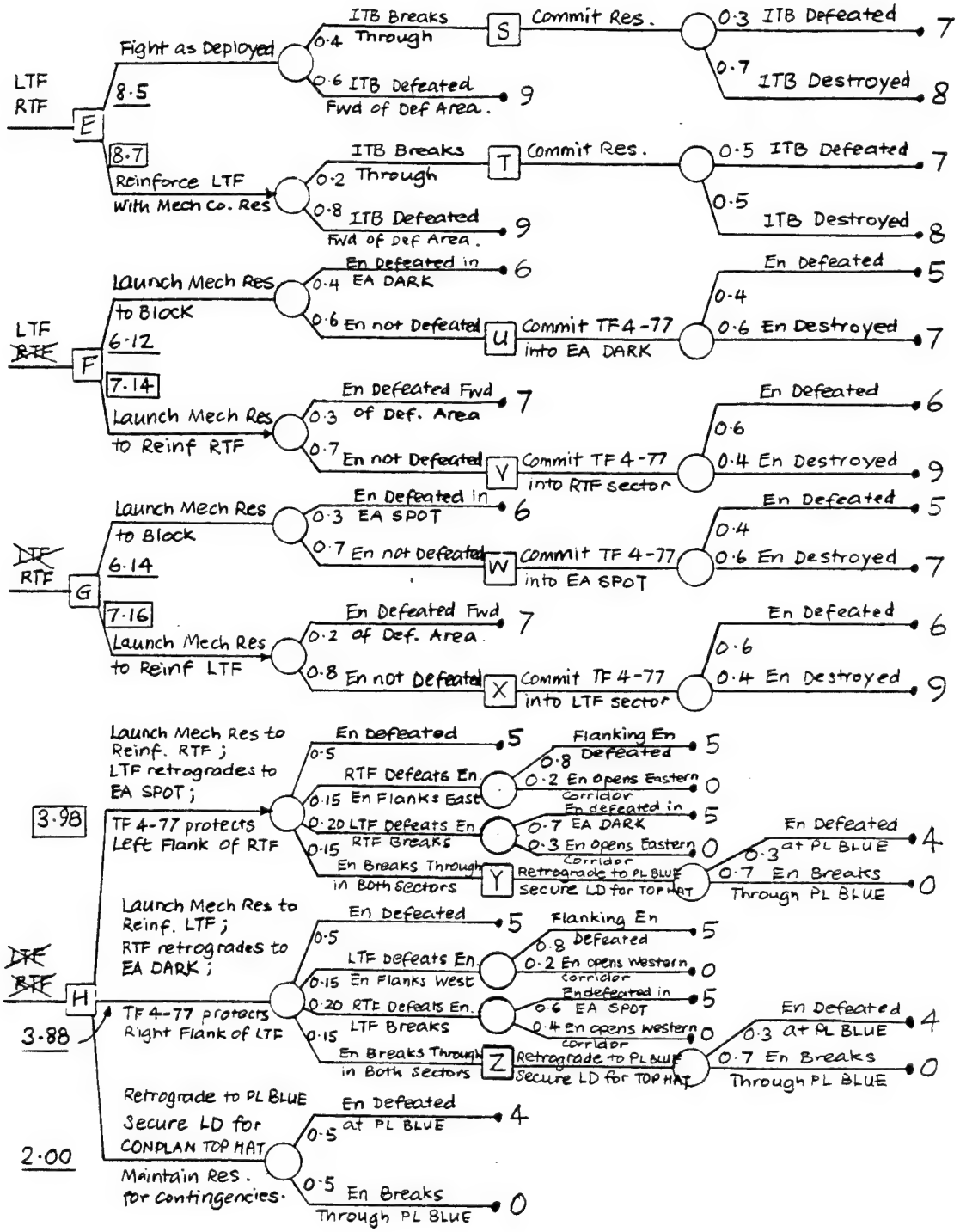


Figure 12. Decision Tree - Branches E to H

Branch F

Branch F corresponds to branch B. The mechanized company reserve is less powerful than the tank company reserve we have in COA 1. Hence, in this COA, we reduce the likelihood of the reserve defeating enemy forces that have penetrated the RTF sector.

Branch G

Branch G corresponds to branch C. As in branch F, we have reduced the likelihood of success for the mechanized reserve to defeat enemy forces that have penetrated the LTF sector.

Branch H

Branch H corresponds to branch D. Again, due to the weaker mechanized reserve, we have reduced its chance of success in the sector it has reinforced compared to the corresponding situation in COA 1.

Conclusion after Analysis of COA 2

The preliminary COA 1 conclusions (with slight changes to account for differences in composition of the LTF and the reserve) apply to COA 2 as well.

Completing the Analysis

Having analyzed all the possible branches to their respective endstates, we can return to the framework stage (refer to Figure 10). We will now complete the computation of the expected values of COA 1 and 2 and conduct sensitivity analysis.

First, we will assess the likelihood of the various scenarios associated with branches A to H under the uncertainty of the location of the enemy main attack. The result of the wargame has enabled us to assess these probabilities with better confidence.

Consider, for example, the branch in which we have chosen COA 1 and the enemy chooses to put in the main attack in the west. We have to decide the probabilities of the following:

1. LTF holds, RTF holds.
2. LTF holds, RTF breaks.
3. LTF breaks, RTF holds.
4. LTF breaks, RTF breaks.

One way to do this is to assume that what happens to the LTF is independent of what happens to the RTF.[9] We can construct a two stage decision tree to elicit an objective assessment.

We judge that if the enemy's main attack is in the west, there is a 50% chance that the LTF will hold. Faced with a supporting attack, we think that there is a 80% chance the RTF will hold. Figure 13 shows the two-stage decision tree.

We repeat the process for COA 1 against an enemy main attack in the east, COA 2 against an enemy main attack in the west and finally COA 2 against an enemy main attack in the east.

The assessment of the likelihood of the immediate outcomes (that is, whether LTF and RTF holds or not), together with the highest expected values from branches A to H, completes the decision tree we have first constructed in the framework stage. Expected values of both COAs are computed. Figure 14 shows the completed decision tree.

Based on expected values, COA 2 appears to be better than COA 1. However, we caution that it is insufficient to base the recommendation of a COA solely on expected values. Additional analysis of the completed decision tree can yield further insights into the tactical problem.

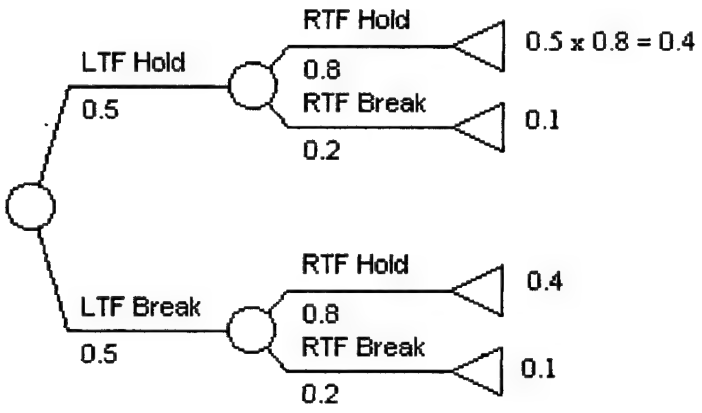


Figure 13. Two-stage Decision Tree to Elicit Probability Assessment

Looking at the decision tree in Figure 14, we can make two general observations:

1. Regardless of which COA is adopted, we have a good chance of succeeding in this part of the mission (that is, the initial defense) if one or both sectors hold. The likelihood of success becomes very low if both sectors fail.

2. Regardless of which COA is adopted, an enemy break through in the RTF sector is marginally more manageable than a break through in the LTF sector. This result is not surprising since the hilly RTF sector is more defensible.

The question we must ask now is: What makes COA 2 a better course of action? Let us examine the contributions of the branches to the expected values. The main contributions to the high expected value of COA 2 comes from branches in which the LTF holds. In other words, we will be less successful if the enemy succeeds in breaking through the LTF sector. Therefore, we should take actions to foreclose the

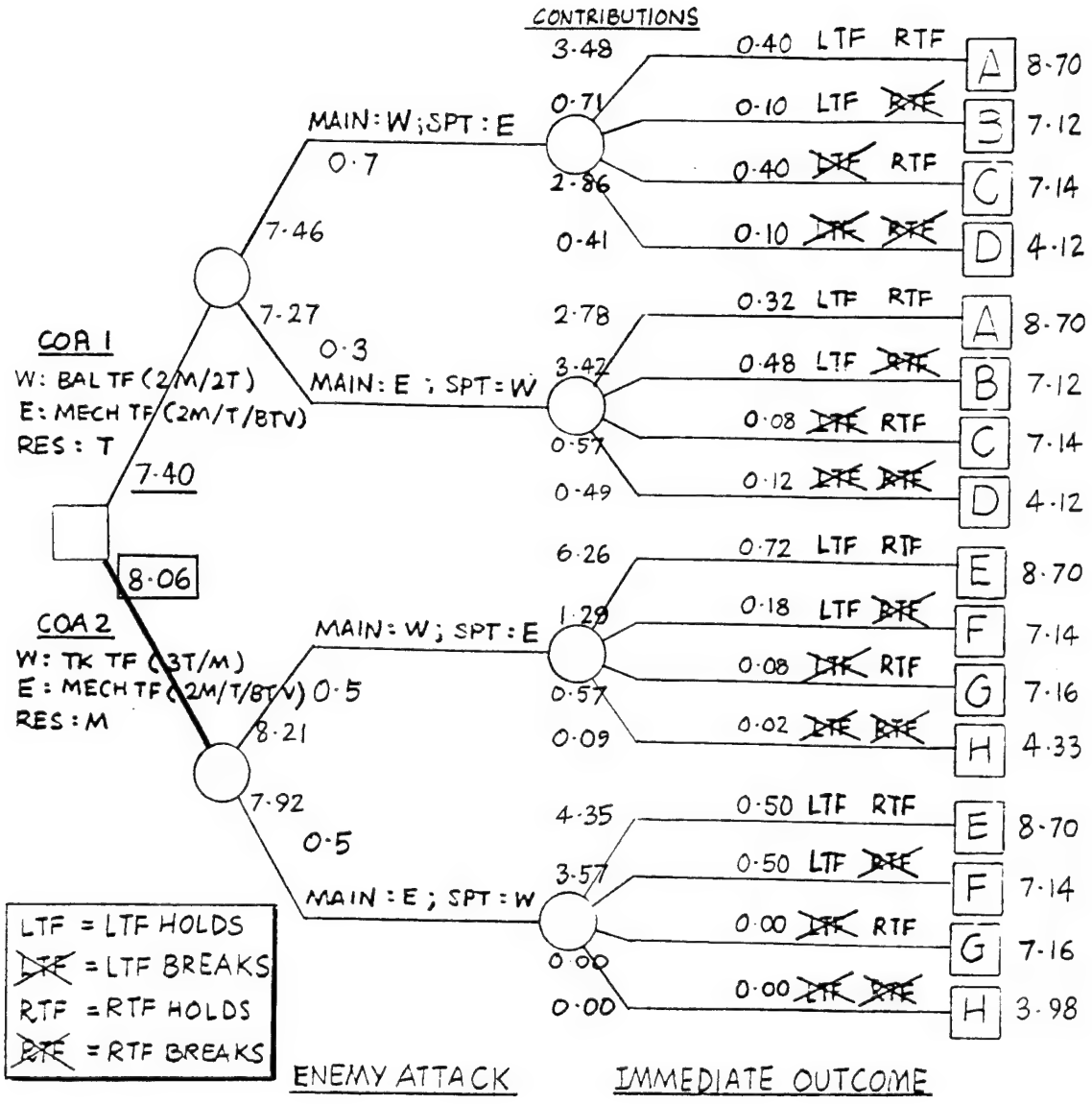


Figure 14. The Completed Decision Tree

possibility of the LTF sector collapsing. We will ensure this by making the LTF the main effort and heavily resourcing this effort with combat support.

The next question is: How can we improve COA 1? We observed that the positive contributions for the expected value of COA 1 come from branches in which we hold out against the supporting attack. For example, one can refer to the branch in COA 1 in which the enemy main attack is in the west and the supporting attack is in the east (top branch of Figure 14). The main contributions to the expected value of 7.460 (that is, 3.480 and 2.856) come from branches in which the enemy supporting attacks were defeated. The same pattern occurs in the other branch of COA 1. Thus, we should ensure that our supporting effort (RTF) at least overmatches the enemy supporting attack. To improve COA 1, we also need to induce the enemy to put the main attack in the LTF sector. Lastly, we note that the actions to improve COA 1 also improves COA 2.

Summary of Analysis and the Recommended COA

Based on the foregoing, COA 2 should be recommended. The tank-heavy task force (LTF) in the west, the main effort, ensures that the LTF sector holds against enemy attack. The mechanized-heavy task force (RTF) in the east, the supporting effort, is adequate to deal with an enemy regiment-sized supporting attack.

We will conceal the concentration of tanks in the LTF sector so that the enemy is more likely to launch the main attack into the LTF sector.

Upon the imminent collapse of a forward defense sector, the mechanized company reserve will be ordered to reinforce that sector. The priority is the LTF sector, followed by the RTF sector.

TF 4-77 will occupy assembly area FIX in the brigade rear to reorganize. On order, TF 4-77 moves forward to occupy assembly area CENTRAL as the brigade reserve. In order of priority, TF 4-77's possible tasks are to reinforce the LTF; reinforce the RTF; attack by fire into EA SPOT or EA DARK from prepared fighting positions; protect the flank of the RTF or the LTF.

EA SPOT in the west and EA DARK in the east will be established behind the forward defense sectors. Here, enemy forces that have penetrated forward defenses will be destroyed by direct, indirect and air-delivered firepower.

Synchronization

Instead of constructing a single monolithic synchronization matrix, we propose that planners construct many modular but smaller synchronization matrices tied to key events. Some of the key events identified are the commitment of the mechanized company reserve into the forward defense sectors, synchronization of battlefield elements in the engagement areas and commitment of TF 4-77. As a suggestion, these modular synchronization matrices can perhaps be pegged to indicators that the key event is imminent.

For example, the launching of reinforcement can be based on an indicator for the collapse of a sector. The planner estimates that the sector will collapse if the task force loses more than half its strength. Working backwards, the planner accounts for deployment, link up, movement and reaction time intervals to determine the latest time to launch. Suppose the time interval is 30 minutes. The planner then estimates the losses that can occur in 30 minutes. Let us say that one-sixth of the task force's strength can be depleted during this time. Therefore, the indicator that will lead to the launching of the

reinforcement can be when the TF in the sector loses about one-third of its strength.

The current method of identifying named areas of interest (NAIs) can still be used. The indicator that initiates the modular synchronization matrix is an observation of the target at the NAI.

Comparison with Analysis using Synchronization Matrix

Using a synchronization matrix to guide planning forces the planner to consider one enemy COA at a time. The matrix is not designed to record other possible enemy options. In theory, planners will complete a synchronization matrix for each combination of enemy COA and friendly COA. Complete analysis of a COA can only be done when one can assess the COA's performance against all the enemy COAs. In practice, the whole process is time-consuming and frequently not completed. This leads to inadequate analysis.

In the benign environment of the U.S. Army Command and Staff College, students seldom complete the whole planning process. The "school's solutions" given to students at the end of the 3d Brigade planning exercise (on which this case study is based) consists of two synchronization matrices: one for COA 1 and one for COA 2. These are reproduced in this thesis at Appendix. One observes that the synchronization matrices are both based on a single enemy COA that is perceived to be the "most likely." Presumably, these matrices are intended to be samples of the complete set of synchronization matrices that are produced. However, the author thinks that a learning point is missed when students do not see how to integrate and analyze information between synchronization matrices of the same COA but for different enemy COAs. Students would have realized that it is very difficult. But when this analysis is not done, planners cannot systematically discover where

the enemy can thwart our well-synchronized plan and determine how to foreclose enemy options or bend the enemy to our will.

Examining the synchronization matrices of COAs 1 and 2 of the 3d Brigade, one finds a well-timetabled battle that assumes the enemy to be a compliant actor. There is nothing in the matrix that alerts the planners to potential problems with the plan. There is nothing in the matrix that suggests what other options the enemy has.

To show that an important part of the analysis is amiss, let us look at the use of the reserve and TF 4-77. From the single enemy COA in the synchronization matrices, planners cannot appreciate the scope and nature of the tasks for which the reserve and TF 4-77 should be prepared. The synchronization matrix approach to planning does not compel the planner to consider the ways he can launch the reserve, much less investigate which is most appropriate. In the sample synchronization matrices, the planner can only assign a priority sector of commitment to the reserve with no guidance concerning likely situations they can face and what is expected of them. The fault of the current planning methodology is that it does not support deeper analysis.

Evaluation of the Proposed Planning Methodology

We will use the yardstick that is developed earlier in this thesis to evaluate the proposed planning methodology. Its assessment will be based on its application to the case study.

Function

The methodology serves the function of COA analysis well. The decision tree construct arranges an unstructured problem into a logical framework by which analysis can proceed. Facts, assumptions and uncertainty are systematically accounted for in the branches of the

tree. The tree construct allows the planner to see clearly the interactions between options, uncertainty and endstates. The information that is presented in the decision tree construct permits planners to gain insight into the problem more readily than with the present synchronization matrix arrangement. Insights into the problem lead to clarity of what needs to be done to bring about success.

Application of Subjective Military Judgment

The decision tree construct allows planners to apply subjective military judgment. They can assess the likelihood of enemy response to our actions and make value judgments on the outcomes (endstates). Planners base these subjective judgments on the wargame. The key attribute of the methodology is the treatment of these subjective judgments during analysis. We recognize that subjective military judgments are soft. Numbers attached to these soft judgments are intended to aid analysis. Careful not to treat soft judgments as hard data, the proposed methodology attaches higher importance to the sensitivity analysis with a view towards gaining insight rather than choosing a COA based on comparison of expected values.

Consideration of All Foreseen Enemy COAs

The decision tree construct explicitly considers all foreseen enemy options. Uncertainties as to what the enemy will do and our estimate of how our actions will influence the enemy's actions are represented as probabilities on the decision tree.

Facilitation of the Wargame

During the development of the methodology, we recognize that the wargame is central to U.S. Army planning doctrine. We realized during concept development that the wargame recording method has an

impact on the planning thought-process since it steers the conduct of the wargame. Hence, we proposed that wargame records should be kept in the form of a decision tree. Recording the wargame as a decision tree facilitates the action-reaction-counteraction cycle since these have similar structure. Decisions and outcomes are chronologically arranged in the decision tree so planners see clearly the sequencing of battlefield events. The new methodology proposed that synchronization among combat elements (Battlefield Operating Systems) can be performed in a modular fashion after the decision tree analysis reveals what needs to be done to best accomplished the mission. We cannot evaluate how useful a decision tree representation (with modular synchronization matrices) is as a decision cue for the commander in battle. However, we think the commander will be more confident, entering the battle with a robust plan, having thought through the enemy options and having made plans to counter them.

Promotion of Insights into the Tactical Problem

The case study analysis showed that planners can gain insight into the problem more readily when information is presented in a decision tree form. With a decision tree, the planner is able to look at actions and outcomes associated with various enemy options. He will be able to see what actions are needed to foreclose enemy options and bend the enemy to our will. He will also be able to see how to array forces to best deal with contingencies.

Identification of Problems, Critical Events and Intelligence Gaps

Decision tree analysis allows the planner to systematically identify potential problems, critical events and key intelligence gaps in the COAs. During sensitivity analysis, planners can be cued to these contingencies. For example, when the planner runs out of own options or

finds that we are unable to foreclose poor outcomes, he recognizes them as cues for potential problems. Decision tree analysis can show where there is a drastic difference in outcomes that hinge on the success of an action. This is a cue for a critical event. In cases where enemy options lead to vastly different outcomes, this is the cue for an intelligence gap.

Encouragement of Planners to Think about Uncertainty

Using the decision tree construct to steer the wargame, planners are encouraged to think about uncertainty and alternate outcomes. As a result of this mental preparation, planners heighten their sensitivity to emerging patterns as the battle unfolds. This in turn enables them to anticipate problems and opportunities in battle.

Support of an Abbreviated Decision Making Process

Given a planning time constraint, the proposed planning methodology advocates that planners do not forgo complete analysis of enemy COAs. Using the decision tree, planners can choose to complete analysis of one friendly COA at a time. Thus, they will have a robust plan of action at the end of planning one COA. In this way, the methodology supports an abbreviated decision making process.

Planners save planning time using the decision tree approach compared to the synchronization matrix approach because the former cuts away duplicated parts of the enemy COAs. When considering the planning effort, the basis of comparison is between the decision tree of a single COA and possibly several synchronization matrices (single COA versus the complete set of enemy COA).

Tracing of the Decision

Laying the wargame record out in a decision tree gives complete visibility to the decision maker. The conclusions of the COA analysis can be traced to the contributing factors. Missed options can be noted. The decision maker can trace the decision made and how it is reached.

Acceptance by the Planning Staff

The commander and staff must feel that the decision tree analysis methodology consistently brings about a good plan in reasonable time. The product of the analysis, the decision tree itself, must also be useful for command and control purposes. In the case study, we were unable to evaluate the latter requirement. However, the author remains confident that the decision tree as an analysis tool will be helpful in bringing about consistent planning success. When commanders and planning staff realize the potential of the methodology, they will accept it.

Conclusion

In this chapter, we have applied the proposed planning methodology to a brigade planning problem. We find that the COA analysis using the decision tree allows planners to arrive at insights that are not commonly accessible when using the synchronization matrix approach. One important attribute of the decision tree that contributes to the ease of forming insights is that it enables planners to consider actions and outcomes of various enemy options. Working across the enemy-option domain then permits the planner build a robust plan that can counter most if not all enemy options.

The methodology possesses most of the attributes of the ideal planning methodology which we discussed in Chapter 2. No matter how good a planning methodology is, the perception of the user is key to its

acceptance as the norm. In the next chapter, we will recommend how to promote acceptance of the methodology and offer some conclusions.

Endnotes

[1] Oliver G. Haywood, Jr., COL, U.S.A.F., Military Doctrine of Decision and the von Neumann Theory of Games, a student thesis, (Maxwell Air Force Base: The Air War College, 1950),67.

[2] The top half of U.S. Army officers at the rank of major attend Command and General Staff Officers' Course at Fort Leavenworth.

[3] U.S. Army Command and General Staff College (USACGSC), "Intelligence Estimate," C310 Fundamentals of Combat Operations, Advance Book, (Fort Leavenworth, KS: USACGSC, August 94), 199-213.

[4] USACGSC, "OPLAN WHITE," C310 Fundamentals of Combat Operations, 283-292.

[5] USACGSC, "CONPLAN TOP HAT," C310 Fundamentals of Combat Operations, 309-313.

[6] Nebraskii doctrine organizes their attacking formations into echelons (ech). These echelons are nested and extend from battalions (bns) to regiments (regts) to divisions (divs), armies and front. Normally, each formation organizes into no more than two echelons. For our purpose, simplified to allow a grasp of the concept, the defending force will meet Nebraskii forces in the following order: 1st ech regts of 1st ech div, 2d ech regts of 1st ech div, 1st ech regts of 2d ech div and 2d ech regts of 2d ech div. This does not include additional reserve force at each formation. They can normally be found in the vicinity of the formation's 2d ech. Using the same nesting concept, one can extrapolate to higher and lower formations.

[7] Extracted from practical exercise solution of CGSC C310 course.

[8] Level III denotes a substantial rear threat such as an airborne/ airmobile force.

[9] The assumption is reasonable because right task force and left task force have separate command elements.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

> Theory cannot equip the mind with formulas for solving problems, nor can it mark the narrow path on which the sole solution is supposed to lie by planting a hedge of principle on either side. But it can give the mind insight into the great phenomena and of their relationships, then leave it free to rise into the higher realms of action. There the mind can use its innate talents to capacity, combining them all so as to seize on what is right and true as though this were a single idea formed by their concentrated pressure--as though it were a response to the immediate challenge rather than a product of thought.
>
> Clausewitz, On War

Introduction

In this concluding chapter, we will draw together the key points of the thesis and highlight the findings of this study. We will present some thoughts about implementing the proposed planning methodology. Finally, we will recommend possible areas for future study.

The Thesis Statement

We started with the perception that the current U.S. Army planning methodology cannot deal with enemy uncertainties adequately. As a consequence, users of this methodology do not always account for possible enemy reactions rigorously when formulating friendly courses of action (COAs). The current approach leads planners to think that synchronization is the primary objective of planning. This is sometimes

done at the expense of a more thorough consideration of a thinking enemy.

While current methodology does turn out well-synchronized plans of action, it has neglected another function of planning. One of the key functions of planning is to mentally prepare the commander to face the uncertainty of the battle. During planning, the commander takes a mental journey down all possible paths into the future to visualize how the battle can unfold. Having considered the possibilities, he can start to build a robust plan; one that can counter most if not all enemy options.

War is a contest of wills between combatants. Thus, the enemy and what he is capable of doing is central to planning friendly COAs. Therefore, a planning methodology that does not adequately consider enemy actions cannot be satisfactory.

This study seeks to develop a planning methodology that can enhance the current procedure for analyzing friendly COAs, particularly when dealing with enemy uncertainty.

The Approach

We began this study by examining the Tactical Decision Making Process employed by the U.S. Army to plan a mission. The planning activity is called the Estimate of the Situation. We note that the step in which planners actually build COAs is the COA Analysis step of the Estimate of the Situation.

In the COA Analysis step, planners adopt a methodology that is chiefly based on a series of wargames. During the wargames, planners play out several friendly COAs against all possible enemy COAs. Using an action-reaction-counteraction cycle, planners build COAs as the wargame proceeds. Based on analysis of the wargame results of each COA, the commander chooses the best friendly COA. In this study, we are

concerned with the conduct of the wargame and how to analyze its results so we can gain the most from it.

In the course of this study, we discovered an insight that determined the approach we will take to fix the planning methodology. We realized that the method by which planners record the wargame results shapes the conduct of the wargame. This in turns influences the train of thoughts. We conclude that the best way to make enemy considerations an integral part of the planning methodology is to incorporate them into the wargame recording method.

The Problem with Synchronization Matrix

Presently, planners record wargame results on a synchronization matrix. This can block the planning thought-process from visiting less obvious but possible enemy options. Using the synchronization matrix tends to make planners think deterministically. To fill up events on a timeline, the planner must hold some battlefield variables constant. The prescribed way to do this is to hold the enemy COA constant. Therefore, each synchronization matrix records a friendly COA against one enemy COA. In theory, planners have to work out several synchronization matrices to represent different combinations of friendly COAs and enemy COAs. In practice, this is seldom done due to time pressure. Consequently, thorough analysis of the friendly COAs against all possible enemy actions frequently is not completed.

The use of a synchronization matrix to direct planning can cause another fundamental problem. By planning against one enemy COA at a time, planners deny themselves insights into what needs to done to best to accomplish the mission. To understand this point, let us consider an analogy. In a personnel records database, each record in the database contains several types of information (fields). One field contains height information about the individual. If a database user

wants to know about the height profile of all the personnel, he or she can view one record at a time or can consolidate all the height information onto one report. Planning against one enemy COA at a time is like viewing database records one at a time. It is better, perhaps, to view what options are open to the enemy at critical points in time during the battle. Presenting enemy options in a time snapshot will allow us to discover which options need to be foreclosed and which option we want to induce him to take. We called this "working across the enemy-option domain." We saw that this is a better way of looking at enemy COAs because the correlation it offers makes it easy for planners to gain insight. The synchronization matrix is not designed to open this perspective up to the planner. We will describe the result of this kind of aggregation in the next section of this chapter.

Using this approach, we can see that the proposed planning methodology will:

1. Reorder the sequence of events in the wargame. We will plan against all possible enemy options at a particular critical point before proceeding to the next one.

2. Change the presentation format of the results. The way we record wargame results directs the planning thought-process. It thus affects the quality of the plan.

3. Enhance the way to analyze the wargame results. By organizing wargame results in a better format, analysis will be more likely to bring forth insights.

The proposed planning methodology will restore the centrality of the enemy to mission planning and help build operations plans that are more resilient to uncertainty posed by the enemy.

Concept of the Proposed Planning Methodology

The need to represent enemy options at various times during the battle prompts us to look at the decision tree construct. The idea is to depict a friendly COA as a branch of a decision tree. It models the choice of friendly options as decision points and enemy responses as chance events. Planners' military judgments about the likelihood of an enemy action occurring and of an outcome of the battle are represented as probabilities. The probability figures are expressions of their beliefs based on wargame results. The possible endstates of the battle are rank-ordered to express the degree to which they support mission accomplishment.

Using Decision Trees to Direct the Planning Thought-Process

The main aim of using decision trees in this methodology is not to prescribe a decision. The input of military judgments are too subjective, in most cases, to produce any basis for decisions. The main aim is to direct the thought process during planning. The intent is to force planners to think about enemy options and the friendly actions required to counter them. In following the decision tree construct, planners will systematically consider all enemy options. Planners will build the friendly COA, one step at a time, always focusing their thoughts on the enemy and his capabilities and how to frustrate him or bend him to our will.

However, there will be little motivation to use decision trees if the end product has no value. The completed decision tree can be used for deeper analysis. Planners can use it to compare COAs. More importantly, they can distill the best of all the friendly COAs to merge them into one robust plan. The current methodology also seeks to perform similar analysis. However, the proposed planning methodology

has the potential to perform it more effectively because information is presented in a better way.

Synchronization

Synchronization of combat elements (Battlefield Operating Systems) remains an important planning task. However, in the proposed planning methodology, we suggest that planners construct smaller modular synchronization matrices tied to key events. Planners currently draw a single synchronization matrix on a continuous timeline that spans each COA. Although it is always possible to group various combat activities that appear on a continuous timeline into modules, the appreciation of the significance of the key events can be lost in the process.

Application of the Proposed Planning Methodology

This work illustrates the application of the proposed planning methodology using two tactical planning vignettes. The first shows how it can be used to analyze a part of the division COA for an attack mission. The second shows how it can be extended to deal with full COAs (that is, COAs with multiple decision points) for a brigade defensive battle.

In both illustrative examples, the new methodology enabled planners easy access to insights into what needs to be done to best accomplish the mission. They show how the methodology compels planners to ask the "what if" questions about enemy's and friendly forces' options. The task of building a robust plan becomes easier because planners have been guided systematically to wargame all foreseeable contingencies and have been assisted in identifying what actions are necessary to counter them.

Having seen the application of the proposed planning methodology, we evaluate its performance against a series of criteria

regarded as attributes of an ideal planning methodology. We conclude that the methodology does enhance the current procedure of COA Analysis and facilitate better planning.

Recommendations

Trial Implementation

Decision trees may seem intimidating to some at first. In fact, they are no more difficult to understand than the decision matrices widely used in the U.S. Army. The topic of decision trees is covered in the core curriculum of many undergraduate courses as well as at the U.S. Army Command and General Staff Officers' Course (CGSOC). Therefore most Army officers will have been exposed to their use.

However, the main purpose of using decision trees in the proposed planning methodology differs from its traditional use in decision analysis. We do not seek to prescribe a decision based solely on the expected value principle. Its main purpose is to direct the thought process during mission planning. The way wargame results are presented in the decision tree format also makes it easier for planners to gain insight.

The CGSOC core curriculum course, C430 Resource Planning and Allocation, already contains a module that suggests an application of the decision tree technique to a tactical problem. However, it uses the traditional analytical approach. The C430 course can perhaps introduce students to the way we propose to use the decision tree.

The U.S. Army can also conduct a trial implementation of the proposed planning methodology in the Command and General Staff Officers' Course. The new methodology could be taught to a group of student volunteers. This experimental group could form a planning staff to participate in a planning exercise together with a control group. If

the experiment is successful, further development of the concept could then take place.

Future Studies

In this work, we represented military judgments about outcome likelihoods with probabilities and rank-ordered preferences of outcomes by a simple scale of military worth. However, we have not been rigorous about how this information should be elicited.

In the area of information elicitation, we should study how methods that have been developed to improve accuracy of input into the decision analysis process can be applied to the proposed planning methodology.

The lack of a scale of military worth is a big obstacle to advances in military decision making. Unlike civilian businesses that can often reduce the basis of decisions to cost, the basis for choosing between courses of action lacks a clear cut measure of effectiveness. A way of determining a single composite measure of military worth is a worthy subject for further study.

Concluding Remarks

We did not address the use of computers, automation and command and control information systems in this work. They will have a profound impact on military decision-making in the future.

We see increased reliance on computer simulations. Attempts are also being made to automate parts of the planning process. We think that these developments will make this work more important, not less.

Computer simulations will make wargames more thorough and faster but will not make more sense out of the increased volume of data. The proposed planning methodology guides planners as to what simulations are to be performed and in what sequence during the wargame. It also

provides a systematic framework for analyzing the data. Information presented in a decision tree allows planners to have easier access to insights into the tactical problem. Since computer technology is no substitute for human creativity and insight, the planning methodology can form the bridge between technology and the user.

APPENDIX

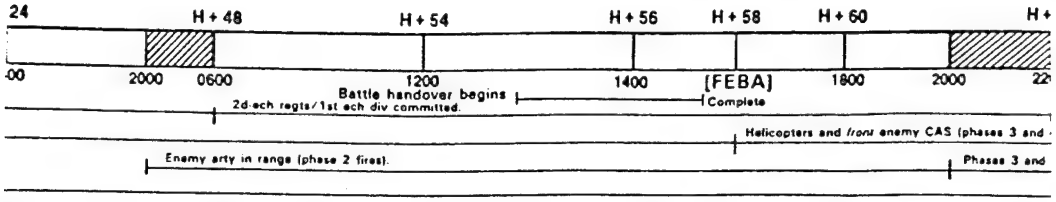
SAMPLE SYNCHRONIZATION MATRICES

In the following pages of this appendix, we have reproduced 3d Brigade's synchronization matrices for COA 1 and COA 2. Due to page-size restrictions for this thesis, each synchronization matrix is broken down and printed on four pages. The synchronization matrix of COA 1 is printed on pages 109 to 112. That for COA 2 is printed on pages 113 to 116.

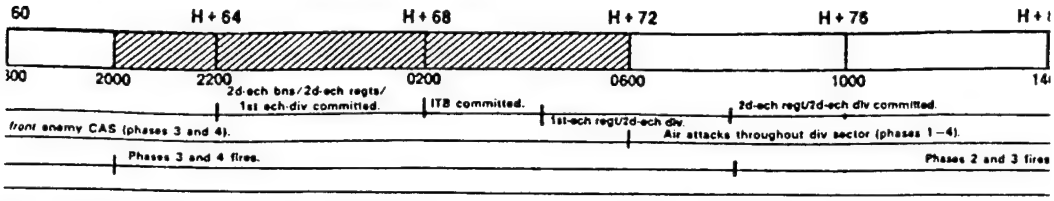
These synchronization matrices are samples given to Command and General Staff Officer's Course students after they had participated in a planning exercise.

Synchronization Matrix for COA 1

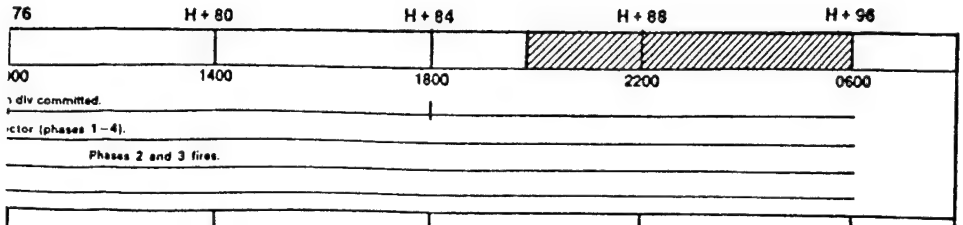
			D-day / H-hour	H + 10	H + 24	H +
TIME			D-1	0600	1600	2000 0600	2000 06
THREAT ACTION			Nebraska *Front* forces continue preparation for combat. Increased intel collection.	1st-ech div attacks across border.	Air attacks throughout div sector (phases 1 and 2).	SOF activity begins; continues throughout the operation.	Enemy
SEVEN BATTLEFIELD OPERATING SYSTEMS	DECISION POINTS		National and corps systems monitor Nebraskii forces.	208th cover begins (H-hour). →		
	INTEL	FOCUS	Monitor natl/corps reports → div.	Corps confirms enemy intentions at H + 8.	Build OB from corps and div reports. →	
		NAI				1, 2, 3, 4, and 5 →
		TAI				
	MANEUVER	SCTY	Increase local security. →		Secure move, occupation. →	
		CLOSE	Disperse/camouflage and prepare def pos (deception). Maintain/resupply. Inc surveillance. →	Prep to move (covert). →	BDE moves H + 10 to H + 18. prepares defense H + 18 to H + 54. →	208th pas begins H + 46. →
		RES	NA		Deploy to AA RAT.	Recon counterattack routes and potential BPs.
		REAR	NA		RISK: no bde TCF. Div TCF? Bde res? →	
		DEEP	NA		Bde priority is 2d-ech regts of 1st-ech div.	
	FIRE SUPPORT		Prepare to support SOF incursions.		Move into sector. Protect movement.	Monitor status of 2-642 FA.
	M/CM/S		Area damage control Construct def pos (survivability and deception).	Prepare for mobility ops in support of bde move. →	Establish barrier plan (PL GRAY to PL ZULU). →	
	ADA		Passive: self-protection. Warning/control statuses: YELLOW/TIGHT. →	Active self-protection. →	Protect movement. Change warning/ control statuses?	Priority to protect prep of def pos. →
	C^2		Maintain normal profile (deception). OPSEC. ↑ →	OPLAN WHITE becomes OPORD. →	Minimize radio. → TAC CP opnl. Estb flank liaison. Main CP in place.	
	CSS		Disperse/camouflage. → Continue maintenance and resupply ops.	FSB preps to spt bde mov to def sector. →	Move CI IV then III, V, IX. → Estb BSA. →	
	DECEPTION		Minimize movement. → Prep def pos near Ottawa → Conceal movement intentions. →			



	55th Avn guard begins H + 48.	Battle handover begins H + 54.	MBA defense begins H + 58.	DP 10: div atk hels to TAI 1?
	What is disposition of 2d-ech regts of 1st-ech div?	2d-ech bns of 2d-ech regts? ITB?		2d-ech div.
1, 2, 3, 4, and 5		1, 2, and 5, then 6 and 7.	6 and 7, then 8 and 9.	
				Area TAI 1.
		TF security elements at BHL; secure div guard force withdrawal	TF security elements engage, withdraw through pas lanes H + 58 to H + 58.	Flank security.
208th pas begins H + 48.	55th Avn Bde begins guard (H + 48). Complete H + 50.	MBA TFs ready at H + 54; avn bde begins pas H + 54 to H + 58.	MBA TFs cover security force withdrawal H + 56 to H + 58, MBA defense begins H + 58.	LTF and RTF each engage and destroy 2 bns, H + 58 to H + 64.
Recon counterattack routes and potential BPs.	Tank co tm priority to LTF.	TF 4-77 begins pas; atch to 3d Bde H + 58.	TF 4-77 closed in AA RAT by H + 60; begins reorganization.	
	2d-ech bns of 2d-ech regts, then ITB.			Bde priority is ITB, then regt of 2d-ech div.
Monitor status of 2-642 FA.	Prep to assist battle handover. 2-642 FA assumes R mission at H + 50.	Support handover. 55th Avn Bde pas.	Priority to LTF, RTF, then res. Bde CFL effective H + 58.	TAI 1.
	Survivability pos (PL YELLOW to PL ZULU).		Barrier plan (PL ZULU to PL BLUE). FASCAM?	Survivability pos (PL ZULU to PL BLUE).
Priority to protect prep of def pos.		Protect battle handover. Change warning/ control statuses?	Priority to C² and CSS.	
		TAC controls battle handover. OO boundaries effective H + 58.		TAC CP repositions. Main CP controls close fight.
	Prepare to refit TF 4-77. Prestock CI V.	Refit TF 4-77. Begin intensive med and maint evac. CI IV → engineers.	Priority: LTF, RTF, then res.	
	Conceal size, location, intentions of bde res.			



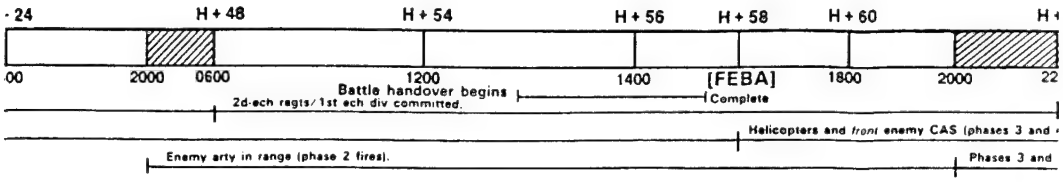
DP 10: div atk hels to TAI 1?	DP 11: div atk hels to TAI 2? DP 16 or 17: where is the ITB? Decision to commit bde res.		DP 17: where is 2d-ech div? Decision to commit TF 4-77.	
2d-ech div. →	→	→	2d-ech bns of regt from 2d-ech div.	
→	12, 13, 14, and 15. 1, 2, and 5.	12, 13, 14, 15. 6, and 7.	8 and 9 then 13, 14, and 15.	12, 13, 14, 15, and 18.
Area TAI 1.	Area TAI 2.		Area TAI 3.	
Flank security. →	→	→	→	→
LTF and RTF each engage and destroy 2 bns, H + 58 to H + 64.	LTF fights, destroys 1 bn vic PL ZULU; RTF fights, destroys 1 bn vic PL YELLOW.	LTF fights, destroys ITB between PL ZULU and PL BLUE; RTF defends south of PL YELLOW.	LTF fights, defeats 1 bn vic PL BLUE H + 74 to H + 77. RTF fights, defeats 1 bn between PL YELLOW and PL ZULU by H + 78.	TFs establish contact with TF 4-77; RTF defends. LTF and TF 4-77 defend, defeat 1 bn vic PL BLUE.
→	TF 4-77 ready at H + 68. Tank co tm to TF 4-77.	WARNORD to TF 4-77.	TF 4-77 committed, assumes center sector at H + 75*. Risk: no reserve. →	→
Bde priority is ITB, then regt of 2d-ech div. →	→	Primary target is 2d-ech div lead elements.	→	Primary target is 42 IMR Bde if committed.
			→	← Priority to TF 4-77, then LTF.
TAI 1.	TAI 2. Move CFL?		MOVE CFL?	TAI 3.
Survivability pos (PL ZULU to PL BLUE). →	→	→	→	Mobility support to TF 4-77.
				→
TAC CP repositions. →	→	TAC CP opnl →		
Main CP controls close fight. →	→	WARNORD to TF 4-77; estb def sector for TF 4-77.	TF 4-77 becomes main effort at H+99.	
→	→			
→	→	→	Maintenance/supply priority to TF 4-77.	→
→	→	→		



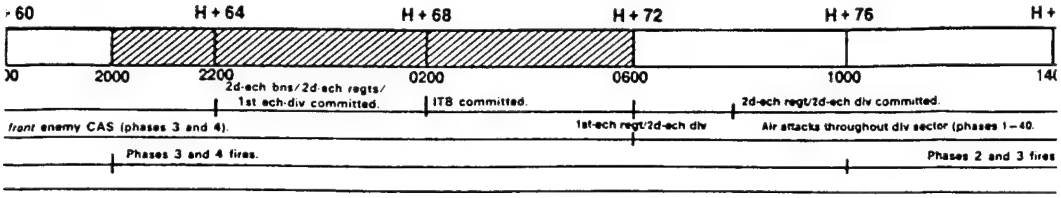
	Where is 42 IMR Bde?			
12, 13, 14, 15, and 18.	1, 2, 3, 4, and 5.			
TFs establish contact with TF 4-77; RTF defends. LTF and TF 4-77 defend, defeat 1 bn vic PL BLUE.	TF 4-77 assumes left sector, defends vic PL BLUE; RTF defends vic PL ZULU. Reorganize			
	LTF now bde reserve;* moves to AA; reorganizes; priority to TF 4-77.			
Primary target is 42 IMR Bde if committed.				
Priority to TF 4-77, then LTF. TAI 3.	Priority to TF 4-77, then RTF.			
Mobility support to TF 4-77.	Priority to countermobility: TF 4-77, then RTF.			
	Priority to reorganizing units.			
	Priority to TF 4-77, then RTF, then res.			

Synchronization Matrix for COA 2

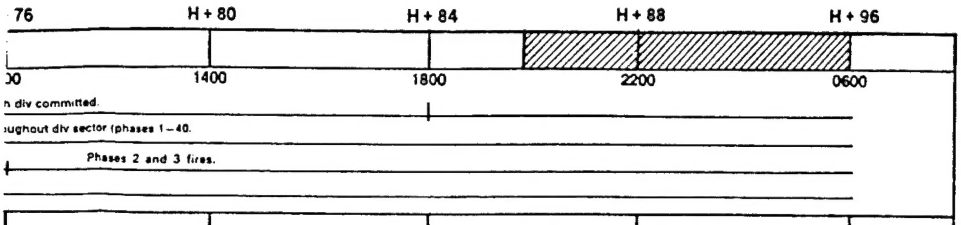
			D-day H-hour		H + 10		H + 24		H +
TIME			D-1	0600		1600	2000	0600	2000	060
THREAT ACTION			Nebraska *Front* forces continue preparation for combat. Increased intel collection.	1st-ech div attacks across border.						
				Air attacks throughout div sector (phases 1 and 2).						
				SOF activity begins; continues throughout the operation.					Enemy	
SEVEN BATTLEFIELD OPERATING SYSTEMS	DECISION POINTS		National and corps systems monitor Nebraskii forces.	208th cover begins (H-hour). →						
	INTEL	FOCUS	Monitor natl/corps reports → div.	Corps confirms enemy intentions at H + 8.		Build OB from corps and div reports. →				
		NAI						1, 2, 3, 4, and 5. →		
		TAI								
	MANEUVER	SCTY	Increase local security. →	→		Secure move, occupation. →				
		CLOSE	Disperse/camouflage and prepare def pos (deception). Maintain/resupply. Inc surveillance. →	Prep to move (covert). →		BDE moves H + 10 to H + 18. prepares defense H + 18 to H + 54. →		208th pas begins H + 46. →		
		RES	NA			Deploy to AA BOLD.		Recon counterattack routes and potential BPs.		
		REAR	NA			RISK: no bde TCF. Div TCF? Bde res? →				
		DEEP	NA							
	FIRE SUPPORT		Prepare to support SOF incursions.			Move into sector. Protect movement.		Monitor status of 2-642 FA.		
	M/CM/S		Area damage control Construct def pos (survivability and deception).	→ Prepare for mobility ops in support of bde move.		Establish barrier plan (PL GRAY to PL SILVER). →				
	ADA		Passive: self-protection. Warning/control statuses: YELLOW/TIGHT. →	Active self-protection. →		Protect movement. Change warning/ control statuses?		Priority to protect prep of def pos. →		
	C²		Maintain normal profile (deception). OPSEC. ↑ →	→ OPLAN WHITE becomes OPORD. →		Minimize radio. TAC CP opnl. Estb flank liaison. Main CP in place.				
	CSS		Disperse/camouflage. → Continue maintenance and resupply ops.	→ FSB preps to spt bde mov to def sector.		Move CI IV then III, V, IX. → Estb BSA. →				
	DECEPTION		Minimize movement. Prep def pos near Ottawa Conceal movement intentions.	→ → →				Conceal size, location, intentions of bde res. →		



	55th Avn guard begins H + 48.	Battle handover begins H + 54.	MBA defense begins H + 58.	DP 10: div atk hels to TAI 1?
	What is disposition of 2d-ech regts of 1st-ech div?	2d-ech bns of 2d-ech regts? ITB?		2d-ech div.
1, 2, 3, 4, and 5.		1, 2, and 5, then 6 and 7.	6 and 7, then 8 and 9.	
				Area TAI 1.
		TF security elements at BHL; secure div guard force withdrawal	TF security elements engage, withdraw through pas lanes H + 56 to H + 58.	Flank security.
208th pas begins H + 46.	55th Avn Bde begins guard (H + 48). Complete H + 50.	MBA TFs ready at H + 54; avn bde begins pas H + 54 to H + 56.	MBA TFs cover security force withdrawal H + 56 to H + 58, MBA defense begins H + 58.	LTF and RTF each engage and destroy 2 bns, H + 58 to H + 64.
Recon counterattack routes and potential BPs.	Mech co tm priority to LTF.	TF 4-77 begins pas; atch to 3d Bde H + 56.	TF 4-77 closed in AA FIX by H + 60; begins reorganization.	
	2d-ech bns of 2d-ech regts, then ITB.			Bde priority is ITB, then regt of 2d-ech div.
Monitor status of 2-642 FA.	Prep to assist battle handover. 2-642 FA assumes R mission at H + 50.	Support handover. 55th Avn Bde pas.	Priority to LTF, RTF, then res. Bde CFL effective H + 58.	TAI 1.
	Survivability pos (PL YELLOW to PL SILVER). Primary/alternate.		Barrier plan (PL SILVER to PL BLUE). FASCAM?	Survivability pos (PL SILVER to PL BLUE).
Priority to protect prep of def pos.		Protect battle handover. Change warning/ control statuses?	Priority to C² and CSS.	
		TAC controls battle handover. OO boundaries effective H + 56.		TAC CP repositions. Main CP controls close fight.
	Prepare to refit TF 4-77. Prestock Cl V.	Assist 55th Avn pas. Refit TF 4-77. Begin intensive med and maint evac. Cl IV → Engineers.	Priority: LTF, RTF, then res.	
Conceal size, location, intentions of bde res.				



DP 10: div atk hels to TAI 1?	DP 11—div atk hels to TAI 2	DP 16 or 17: Decision to commit bde counterattack.		
2d-ech div. →			2d-ech bns of regt from 2d-ech div.	
	12, 13, 14, and 15. 1, 2, and 5.	12, 13, 14, 15. 6, and 7.	8 and 9 then 13, 14, and 15.	12, 13, 14, 15, and 18.
Area TAI 1.	Area TAI 2.			Obj MELEE (TAI 3).
Flank security. →				
LTF and RTF each engage and destroy 2 bns, H + 58 to H + 64.	RTF destroys one bn south of PL ZULU; LTF destroys one bn PL ZULU to PL SILVER.	RTF defends vic PL SILVER. LTF destroys ITB PL SILVER to PL BLUE. ITB	RTF defeats one bn vic PL SILVER. LTF fights, blocks one bn vic PL BLUE.	RTF defends; LTF blocks. TF 4-77 destroys one bn (+) vic obj MELEE.
	TF 4-77 ready at H + 66.	WARNORD TO TF 4-77. Move →	Pas → Contact	Mech co tm priority to TF 4-77. →
Bde priority is ITB, then regt of 2d-ech div. →		Primary target is 2d-ech div lead elements. →		Primary target is 42 IMR Bde if committed.
			←	Priority to TF 4-77, then LTF, then RTF.
TAI 1.	TAI 2.		Move CFL? Estb RFL	
Survivability pos (PL SILVER to PL BLUE). →	←	Survivability pos (subsequent) PL SILVER to PL BLUE. →	→ ←	Mobility support to counterattack.
	→	Priority to bde counterattack. →	→	Priority to counter-attack.
TAC CP repositions. →	→	TAC CP Opnl. →		
Main CP controls close fight. →	→		TF 4-77 becomes main effort at H + 76.	
→				
			→ ←	Priority to counter-attack.
		→		



	Where is 42 IMR Bde?			
12, 13, 14, 15, and 18.	1, 2, 3, 4, and 5.			
Obj MELEE (TAI 3).				
RTF defends; LTF blocks. TF 4-77 destroys one bn (+) vic obj MELEE.	TF 4-77 assumes left sector vic PL SILVER. RTF defends vic PL SILVER. Reorganize.			
Mech co tm priority to TF 4-77.	LTF to AA; reorganize.			
Primary target is 42 IMR Bde if committed.				
Priority to TF 4-77, then LTF, then RTF.	Priority to TF 4-77, then RTF.			
Mobility support to counterattack.	Survivability Posns, PL SILVER TO PL BLUE			
Priority to counter-attack.	Priority to reorganizing units.			
Priority to counter-attack.	Priority to TF 4-77, then RTF.			

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